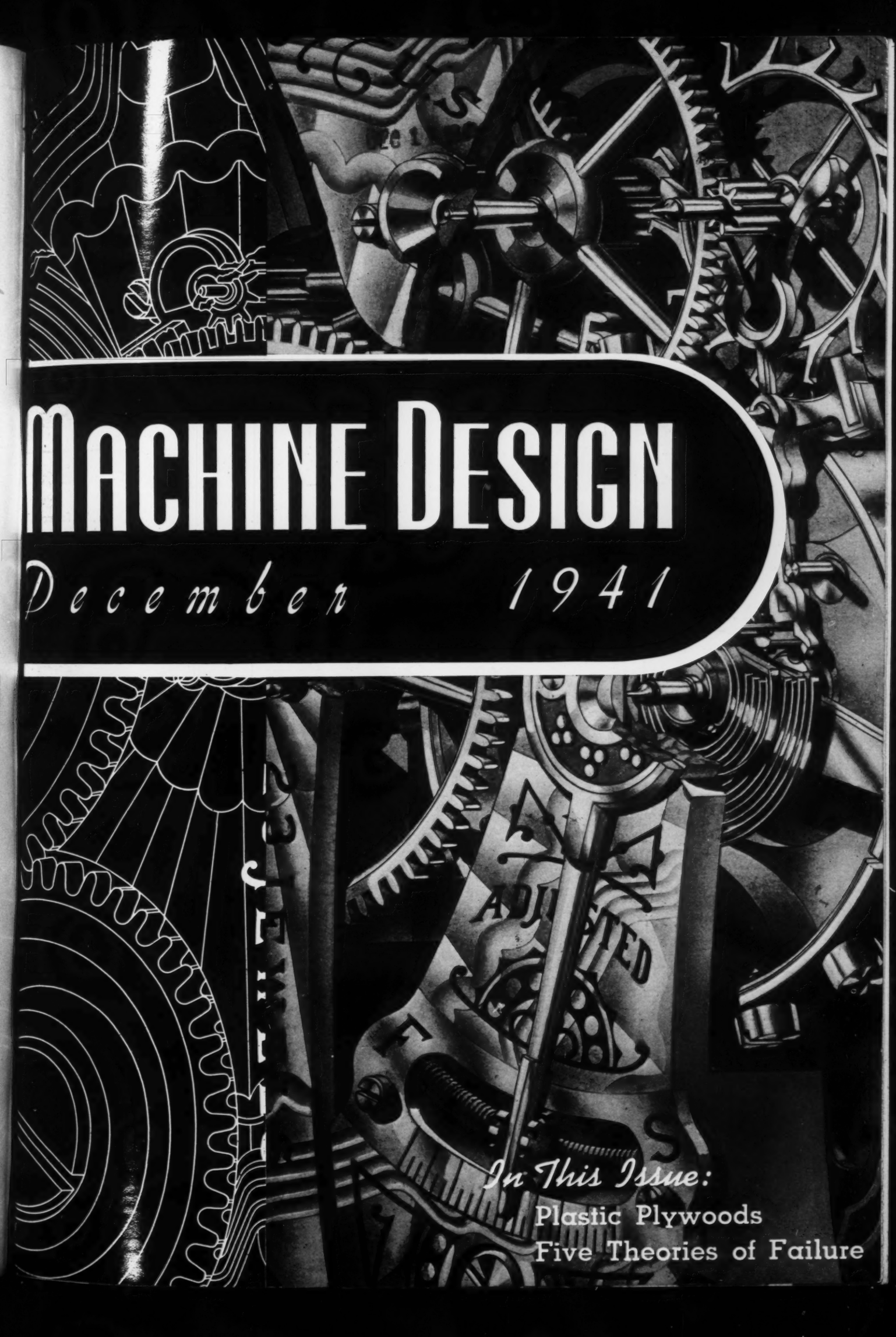


MACHINE DESIGN

December 1941

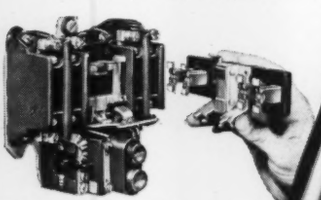
In This Issue:

Plastic Plywoods

Five Theories of Failure

Everything's *Covered* with Dust *Sir*

Dust is always a nuisance, but it's something far more serious when it interferes with the performance of motorized machines in these days of top-speed production. Thus Cutler-Hammer Motor Control is a doubly important asset NOW. *This* Motor Control uses dust-safe VERTICAL contacts exclusively . . . VERTICAL contacts that *can't* collect dust and dirt . . . VERTICAL contacts that *stay* clean to work better and last *longer*. Its recognized record for dependable performance is proof of this outstanding superiority in design and construction. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

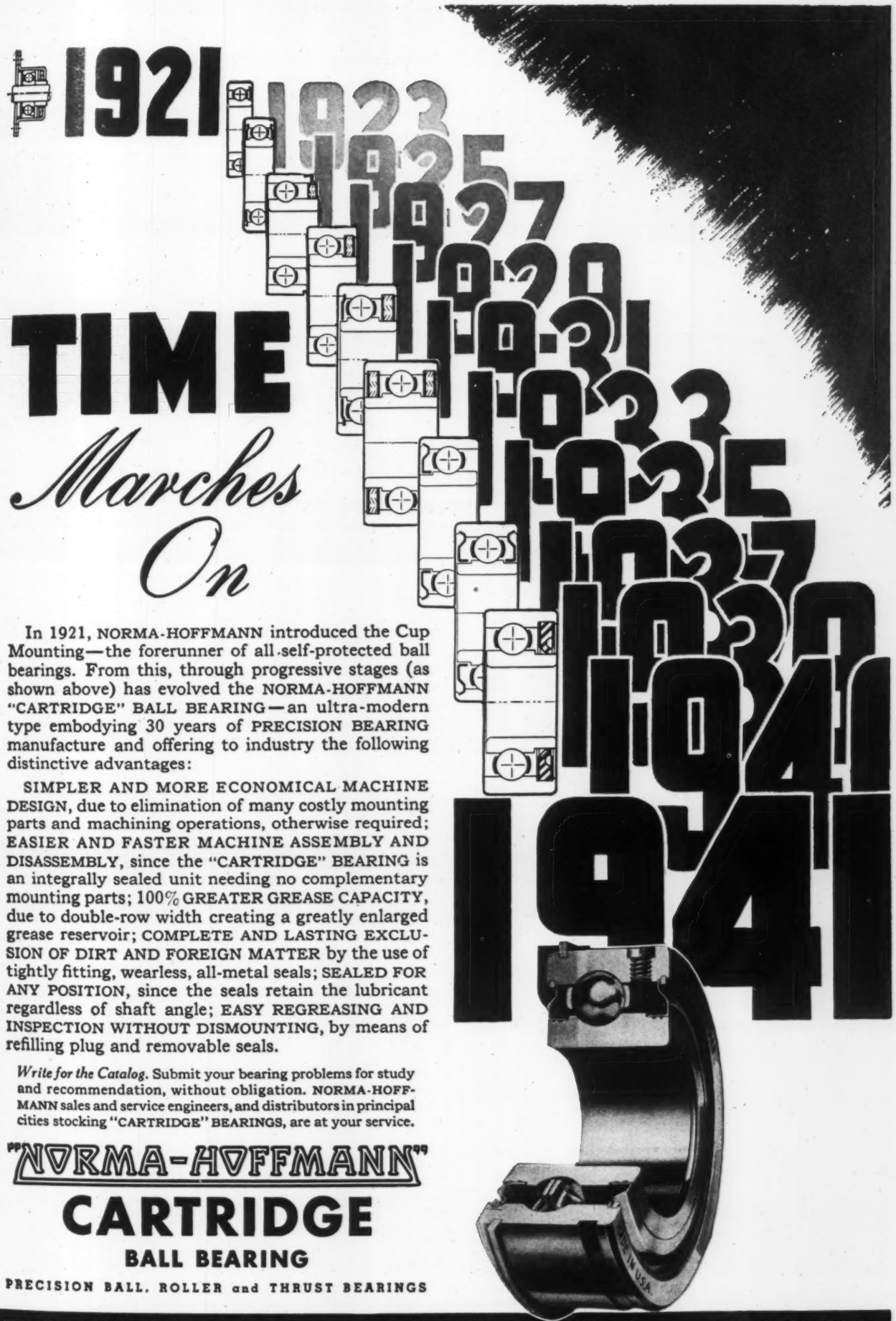


Cutler-Hammer *Vertical* Contacts are the mark of *better* Motor Control, another extra dividend on Cutler-Hammer's unequalled specialized experience and decades of Motor Control leadership.

Getting down old records is always a dirty job . . . for dust settles on horizontal surfaces everywhere whether these surfaces are shelves in an office or parts inside motor control in a factory.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Dust Safe VERTICAL *Contacts*



TIME *Marches On*

In 1921, NORMA-HOFFMANN introduced the Cup Mounting—the forerunner of all self-protected ball bearings. From this, through progressive stages (as shown above) has evolved the NORMA-HOFFMANN "CARTRIDGE" BALL BEARING—an ultra-modern type embodying 30 years of PRECISION BEARING manufacture and offering to industry the following distinctive advantages:

SIMPLER AND MORE ECONOMICAL MACHINE DESIGN, due to elimination of many costly mounting parts and machining operations, otherwise required; EASIER AND FASTER MACHINE ASSEMBLY AND DISASSEMBLY, since the "CARTRIDGE" BEARING is an integrally sealed unit needing no complementary mounting parts; 100% GREATER GREASE CAPACITY, due to double-row width creating a greatly enlarged grease reservoir; COMPLETE AND LASTING EXCLUSION OF DIRT AND FOREIGN MATTER by the use of tightly fitting, wearless, all-metal seals; SEALED FOR ANY POSITION, since the seals retain the lubricant regardless of shaft angle; EASY REGREASING AND INSPECTION WITHOUT DISMOUNTING, by means of refilling plug and removable seals.

Write for the Catalog. Submit your bearing problems for study and recommendation, without obligation. NORMA-HOFFMANN sales and service engineers, and distributors in principal cities stocking "CARTRIDGE" BEARINGS, are at your service.

"NORMA-HOFFMANN"

CARTRIDGE

BALL BEARING

PRECISION BALL, ROLLER and THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N., STAMFORD, CONN., U.S.A. • FOUNDED 1911

Topics

INDICATIVE of the possible savings in materials is the substitution of cellulose nitrate plastics for lowly shoe lace tips. One pound of plastics replaces three pounds of metal in making these tips. This year alone the new tips will release 500,000 pounds of metal, principally tin.

♦

RULING machine developed by the Bureau of Standards for graduating meter bars is now in regular use and progress is being made on similar equipment for stepping off decimeter and shorter scales. Manufacturers producing interchangeable parts for airplane engines and other vital military equipment are sending more than 800 requests each month for the calibration of high-precision end gages.

♦

LARGEST number of employes engaged by one organization solely in the manufacture of airplanes is credited to the affiliated companies, Lockheed Aircraft Corp. and Vega Airplane Co. Lockheed has 39,000 on its payrolls while Vega has 11,000, a total of 50,000.

♦

USED to check the diameter of filament wire, a super sensitive set of scales is used which is accurate to within 40 billionths of a pound.

♦

ON THE tenth anniversary of the introduction of neoprene, production has increased from 250 pounds to approximately 1,500,000 pounds a month. Next year it is expected to be well over three times the present. Originally costing a dollar a pound, the price has been radically reduced.

♦

MINIMUM number of steel specifications, compositions and sections necessary to meet the requirements of national defense is a request of OPM. The project is being carried out by the American Society for Testing Materials, Society of Automotive Engineers and the American Iron and Steel Institute in collaboration with the War and Navy departments. The new classifications will be designated as National Emergency Steel Specifications. Carbon and alloy steel plates and aeronautic steels will be the first listed.

♦

RECENTLY, a Martin "Baltimore" medium bomber dived in test at a speed of 560 miles per hour. The dive was not vertical but at an angle of 65 degrees. Faster than the muzzle velocity of a .45 caliber pistol bullet, bombers of this type are being built for the Royal Air Force. They are expected to out-perform pursuit planes that might be used against them. Being heavily armed with guns trained in all directions, the ship is also designed to handle as a fighter.

♦

MORE than half the total production of the many Westinghouse plants throughout the country is devoted to defense work. Recently the merchandise plant at Mansfield received an Army contract for 37-mm armor-piercing shell. These shells, known as three-piece shot, have a forged steel body with an alloy steel penetrating point or cap and an aluminum "windshield" which cuts down the wind resistance.

♦

NEW and lighter shade of "machine tool gray" has been adopted by National Machine Tool Builders' Assn. as the standard finish for machine tools. Although the lighter shade shows dirt and fingerprints more easily than the older color, better light-reflection values increase the efficiency of operators. Also, they take greater pride in their machines and, as a result, produce better workmanship. One large user has reported a 33 per cent increase in lighting at the working height.

♦

SHORTAGES in phenolic and urea resins as well as alternative plastics indicate that during the emergency wood will again be used for cabinet and decorative uses.

Plastic Plywood Comes of Age

By John W. Greve

PLASTIC plywoods are rapidly assuming increased importance in design. They have been developed to the extent that they now are dependable engineering materials which may be applied with accuracy and without fear of failure at the bond.

Availability and ease of fabrication as well as adaptability to aircraft production makes the material particularly valuable in the defense program. Diversion of carbolic acid to the manufacture of ex-

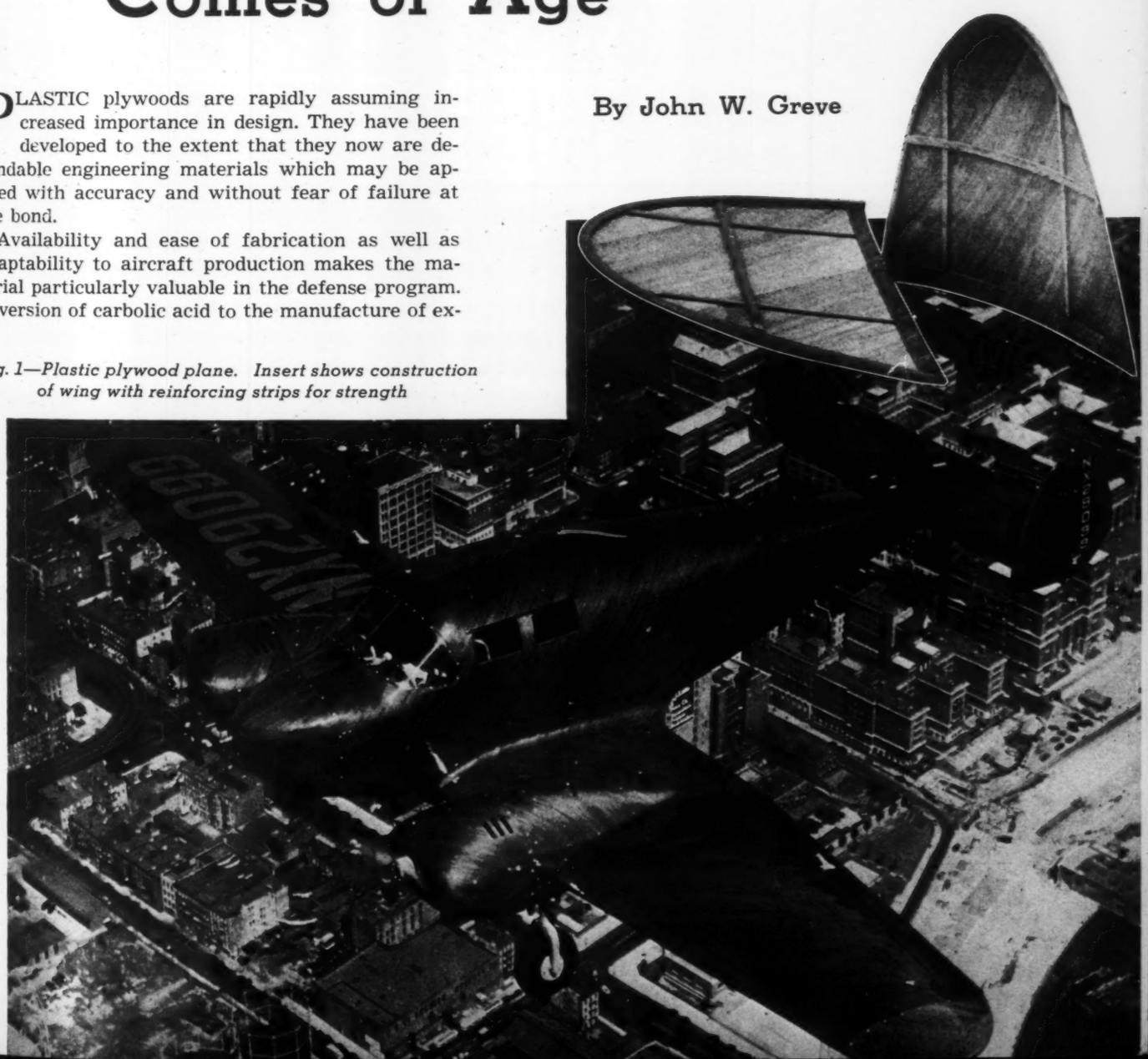


Fig. 1—Plastic plywood plane. Insert shows construction of wing with reinforcing strips for strength

plosives instead of to phenolic resins is not critical for plywood since 90 per cent is cellulosic structure, the remaining 10 per cent being resin.

Typical of the progress in both materials and application is the Langley plane in *Fig.* 1. Structure and skin are molded in integral sections of thin strips of resin-treated Honduras mahogany. This wood was chosen because it is the least dense satisfactory wood that will withstand the molding pressures used. A vinyl resin is employed principally because of its strength, flexibility and lower weight. Engine cowlings, however, are molded with a phenol formaldehyde because of the greater heat from the engines. In contrast with this application, which demands the best possible

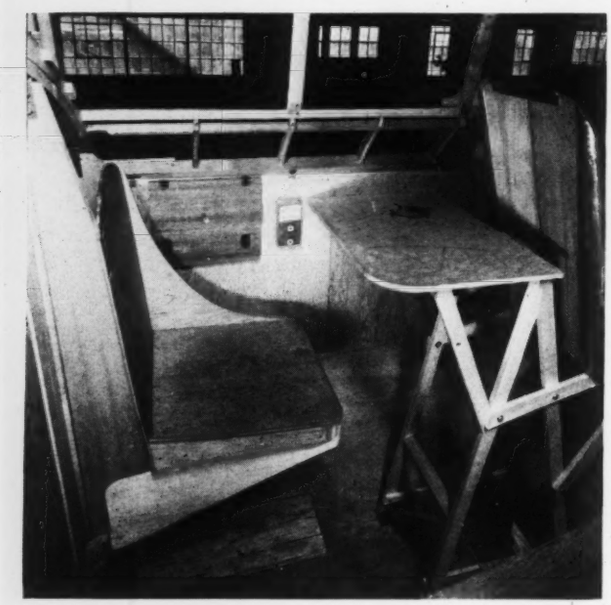


Fig. 2—Mock-up section for Boeing "Flying Fortress"

physical properties, is the "mock-up" shown in *Fig.* 2 of a model interior section of a Boeing "Flying Fortress."

Resin bonds and surface coatings render plywood impervious to water, essential requirements for both aircraft and watercraft, *Fig.* 3. Also, the humidifier in *Fig.* 4, in addition to taking advantage of the warm tones of walnut veneer, must be water resistant, even though designed for interior use. This design won an award in a recent *Modern*

Effects of Bonding Pressures*

Wood Specie	Bonding Press. (lb./sq. in.)	Spec. Grav.	Tensile Strength (lb./sq. in.)	Compress. Strength (lb./sq. in.)	Shear Strength (lb./sq. in.)	Creep (per cent)
Birch (solid)		.63	10,100	6,200	2,020	....
Birch	200	.77	12,550	8,580	7,240	15
Birch	500	1.05	19,160	11,720	11,540	17
Birch	1000	1.30	25,740	14,220	16,180	19.5
Birch	1500	1.35	25,030	14,540	16,360	....
Poplar (solid)		.40	6,100	3,550	1,100	....
Poplar	500	.82	13,420	8,460	8,220	12.0
Poplar	1000	....	18,600	11,600	12,400	14.5
Poplar	1500	1.32	23,570	14,540	16,460	....

*Based on information from T. D. Perry, Resinous Products & Chemical Co. and J. Delmonte, Plastics Industries Technical Institute.

Fig. 3—Combined strength, light weight and resistance to elements make resin-bonded woods ideal for water-

Plastics competition. Another interesting and significant application is for floats on light planes. Phenol-bonded birch plywood of semimonocoque construction stiffened with ash keel and chime stringers, provides high strength-weight ratios. This type of float offers less surface drag than metal ones with lapped and riveted construction.

Plastic-bonded plywoods group logically into two general classifications depending on the nature of the bond utilized and the character or direction of grain in the sheets. These classifications are:

1. Type of bond
   a. Cold setting
   b. Hot setting
      1. Low pressure
      2. High pressure
   c. Impregnated
2. Character of veneer composition
   a. Plywood
   b. Laminated
   c. Combination of wood species.

Cold-setting bonds include glues such as casein and soy bean, but these are only for wood veneers subject to inside exposures. Urea formaldehyde with a catalyst forms a four-hour live adhesive that cures without application of heat. These bonds, however, can be physically improved by curing at temperatures of about 150 degrees Fahr. The application and strength required determines whether or not cold-setting resins may be used.

Hot-setting bonds are principally phenolic, cured at temperatures between 200 and 300 degrees Fahr. for 5 to 20 minutes. The pressure used in curing affects markedly the properties of plywood. Pressures between 50 and 250 pounds per square inch are grouped as low pressure and 500 to 2000 pounds per square inch as high pressure. Higher pressures, although increasing production costs and restricting many types of fabrication, generally improve the tensile, compressive and shear strengths greatly up to pressures of 1000 pounds per square inch. Wood species seem to have more equal properties in the higher ranges.

Creep and cold flow characteristics, so important in stressed parts, suffer as the bonding pressures increase. This is probably caused by a breakdown of the wood structure. Shown in the accompanying table are the effects of bonding pressure on physical properties. In *Fig.* 6 are two compression test

specimens from Messrs. Bernhard, Perry and Stern's A. S. M. E. paper "Superpressed Plywood." One is cured at 1000 and the other at 1500 pounds per square inch. In addition to being more costly, the advantages of increased pressure are questionable with respect to compression strength.

Impregnated materials, being more costly to produce, are not used extensively except where the ultimate in physical characteristics is required. Plastic-bonded plywood has the characteristic of wood reinforced with plastics, whereas impregnated plywood has the nature of plastics reinforced with wood.

Increasing the number of laminations and decreasing their thickness, resulting in partial impregnation during early stages of curing, causes plywood to approach the character of impregnated materials. The breakdown of cellulosic structure at high pressure previously discussed does not necessarily happen with fully-impregnated materials, the reason being that the resin carries the loads instead.

Character of the wood composition is determined by the type of application and whether strength should be uniform in all directions or not. Plywood, strictly speaking, is reserved for built-up layers having the grain in various directions, usually alternate layers being perpendicular, *Fig.* 5. Sometimes, however, parallel layers are grouped with periodic cross layers. For gears, the grains revolve about 30 degrees between layers so that the cut teeth will be "grain-strengthened".

Laminated wood has the grain parallel for each layer to produce the maximum strength in one direction. Struts for airplanes are typical of this type. If thin sheets are used, it is possible to produce struts of any desired length by staggering and splicing. In this way it is also possible to build-up sections according to the physical requirements by tapering toward one or both ends.

Combination of wood species may be either plywood or laminated wood in structure but has been grouped separately for convenience. Various woods may be bonded to produce a desired surface or property. For instance, a thin veneer of a rare wood may be used as a surface with a core of a cheaper or stronger wood. Another example is an airplane cabin lining where the exposed surface is walnut for appearance, the core balsa for lightness and the back fiber for strength.

Fig. 4—Below—Conditions of humidity necessitaet waterproof cabinet for humidifier

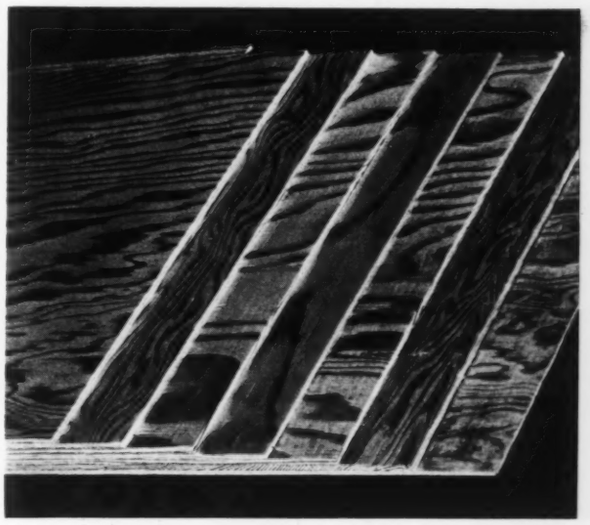
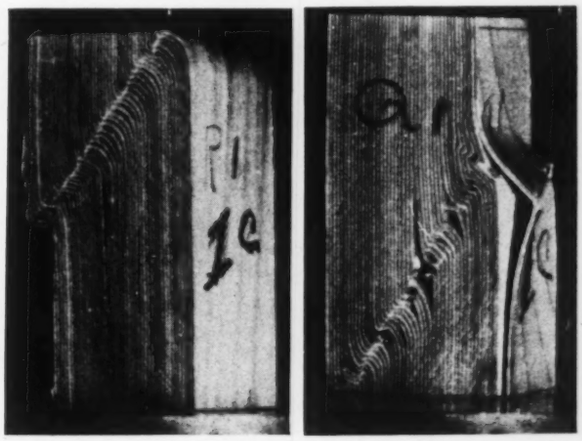


Fig. 5—Above—Construction of plywood using cross-grained layers of veneer

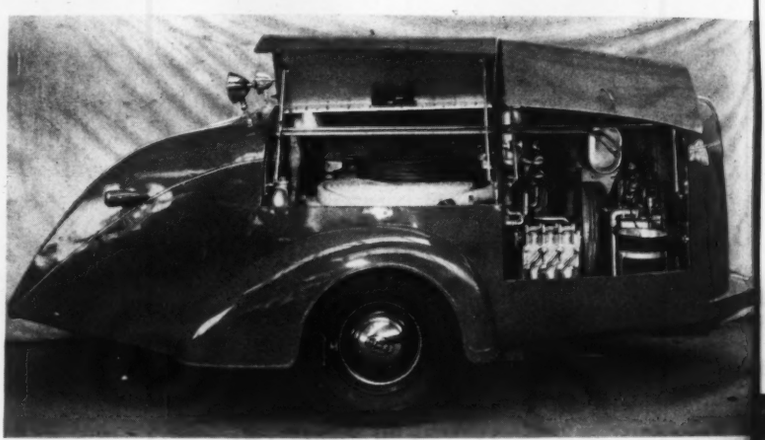
Fig. 6—Below—Compression specimens of 85/48-inch birch bonded at 1500 pounds per square inch and 81/48-inch birch bonded at 1000 pounds are shown at left and right respectively. Higher pressure affected strength only slightly in this case



Most commonly used woods are birch, poplar, gum, spruce and fir. Birch gives stronger plywoods than either poplar or gum, especially in the low-pressure groups. As mentioned previously, how-

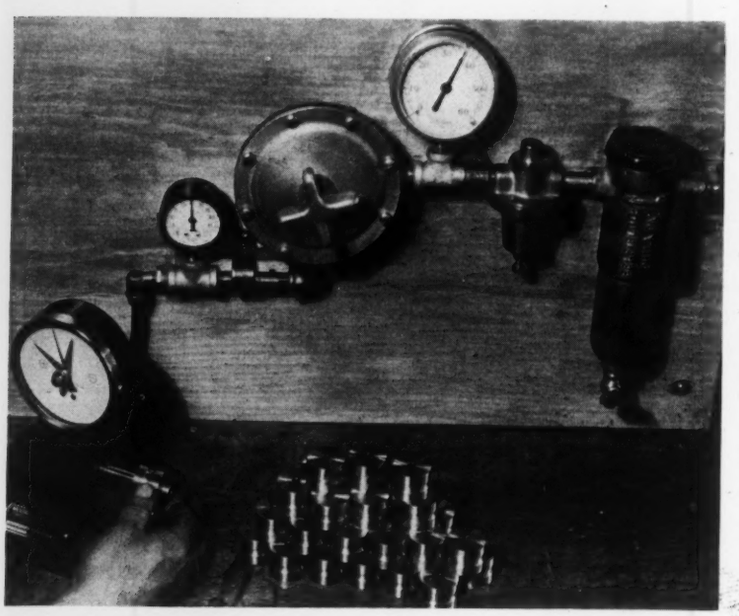
(*Concluded on Page* 128)

Scanning the field for IDEAS



Compact and effective is the design of this mobile fire extinguisher designed by the Food Machinery Corp. Attached to a motorcycle as a side car, the unit is capable of producing a fog blanket using 600 pounds per square inch pressure as compared to conventional 150 to 200 pounds. Intended for industrial uses or defense work involving bomb fires or sabotage, the attractive "streamlined" unit contains a small two-cylinder, air-cooled gasoline engine, a three-stage, horizontal high pressure pump driven by roller chain, a 50-gallon tank for water or chemicals as well as a hose mounted on a live reel, first aid kit and other fire fighting accessories.

Fog blanket is produced by the hose nozzle which, at the high operating pressure, atomizes the water into an exceedingly fine spray. The nozzle is adjustable to give varying sprays or a full stream at high pressure.



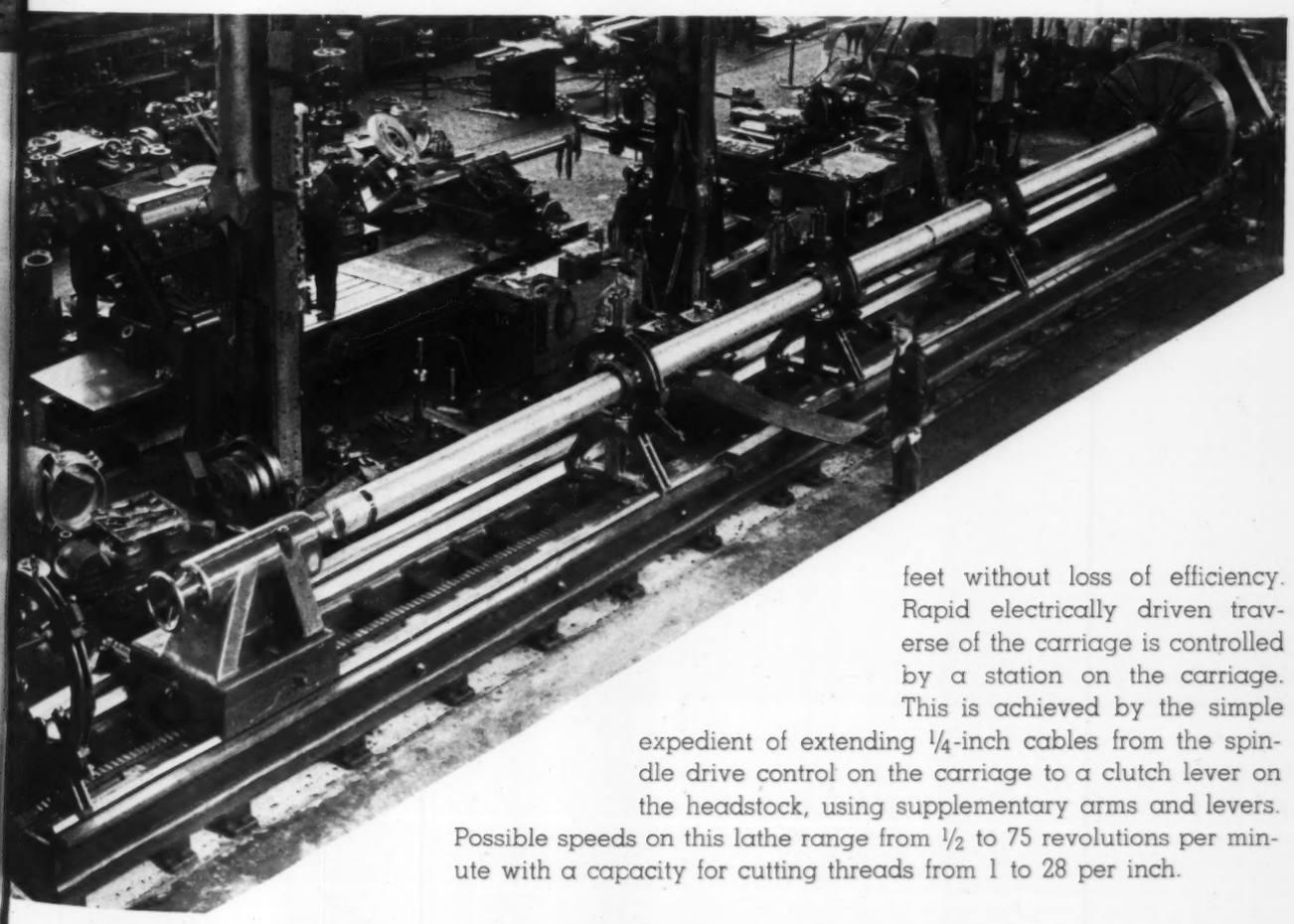
Air nozzle points in the pneumatic comparator at left provide highly accurate and sensitive "fingers" for measurement. Designed by the Moore Products Co., the parts do not touch the piece being gaged and accordingly cannot wear. Clearance between the workpiece and the nozzles, which are diametrically opposite, controls the amount of air escaping. This affects the drop in air pressure which in turn indicates on a dial the size of the piece being measured.

Internal bore gaging, especially for small holes and long tubes, is simplified by this method. Out-of-roundness is also easily measured by rotating the workpiece. In addition, taper and "bellmouth" are readily checked. Grease or dirt have no effect on readings because the high pressure jets instantly blow the surface clean.

Center of gravity support shown at right is effected by rubber mountings which isolate the multidirectional vibrations of radial engine for Douglas aircraft. Link connections to the mounting ring are not installed but are shown assembled in the insert. The bonded rubber units, designed by Lord Mfg. Co., effectively absorb vibrations of both the engine and propelier and provide a high degree of stability to the assembly.

Roller chain feed obviates lead screw on giant lathe shown below and designed by the Washington Iron Works. Capable of cutting equally accurate threads along the length of the lathe bed, the chain feed provides many useful features. Chief of these are rapid traverse of carriage and flexibility of lathe length by adding bed sections and increasing chain length. This flexibility is especially important during the present need for large defense production.

It has been estimated that the bed could be as long as 200 feet without loss of efficiency. Rapid electrically driven traverse of the carriage is controlled by a station on the carriage. This is achieved by the simple expedient of extending 1/4-inch cables from the spindle drive control on the carriage to a clutch lever on the headstock, using supplementary arms and levers. Possible speeds on this lathe range from 1/2 to 75 revolutions per minute with a capacity for cutting threads from 1 to 28 per inch.



Applying Theory of Elasticity

Part XI—Theories of Failure

By R. E. Orton
Chief Engineer
Acme Steel Co., Chicago

THIS, the concluding article of R. E. Orton's series, discusses comparatively the five popular theories of failure and indicates the magnitude of variations in stress calculations that may be obtained. Consideration of the facts presented are invaluable because, as the author points out, the engineering profession must conserve materials in both the present emergency and the industrial struggle that is bound to follow. One of the best ways to do this is to apply more accurate stress analysis in design. In recognition of the importance of the subject and the interest created by the articles, the entire series will be reprinted as a booklet available at nominal cost, making a complete, handy and useful reference

WHAT combination of stresses will result in failure?" This has been a perplexing problem since the beginning of stress analysis. The strength of a material under simple stress may be determined by standard tests, but parts in service are not always in a simple state of stress (see References* 1 and 2). Testing of models under a complex state of stress is not easy, and is seldom commercially feasible. It is therefore necessary that some rule be evolved by which the complex state of stress may be reduced to an equivalent simple stress insofar as failure is concerned.

Structurally, a part has failed when it becomes dimensionally unsuitable for the service for which it was intended. This may be due to wear, corrosion or other types of deterioration not directly related to the condition of stress. With these, therefore, we are not concerned in this series. Failure also may be due to a plastic yielding of some portion, so that when the loads are removed the original shape is not completely regained; or due to continual yielding at an excessive rate, generally termed "creep" and usually associated with high temperatures (Reference 3); or due to the continual repetition of the loads, resulting in a "fatigue" fracture (Reference 4). With these we *are* concerned.

It will be assumed that the stresses are fully known so that it is not necessary to consider the imperfections of the actual material or the effect of stress raisers due to notches, fillets, imperfect surfaces, etc. The discussion, then, is concerned solely with the question of what combination of stresses is responsible for a plastic yield, an excessive creep rate or a fatigue failure.

An elemental prism under the general state of stress is shown in *Fig.* 106. It is oriented parallel to arbitrarily chosen X, Y and Z coordinate axes. One normal and two shear stress components act on each of its six faces. From considerations of static equilibrium, the stresses on opposite faces are equal. Opposing shear couples will also be equal, so that $v_{xy} = v_{yx}$, $v_{xz} = v_{zx}$ and $v_{yz} = v_{zy}$. Three normal and three shear stresses are therefore sufficient to describe the condition of stress in any direction and at any point.

Shear Vanishes on Two Faces

Rotation of the prism about a centroidal axis parallel to the X axis will disclose a position for which v_{yz} and v_{zy} will vanish. Further rotation about a second axis, parallel to the Y axis, will cause v_{xz} and v_{zx} to vanish. Thus, as illustrated by *Fig.* 107, a position of the prism will always be found that will leave two opposite faces free from shear stress, the normal stress remaining on these faces then being a principal stress.

It is to be noted further that *Fig.* 107 illustrates also the general case of two-dimensional stress. The principal stress, S_z, is the "third-dimension" stress due to the condition of plane strain, or is zero in the case of plane stress. As previously demonstrated in the discussion of two-dimension stress (Reference 5), rotation of the prism about an axis parallel to the Z axis will disclose a position where the remain-

* References listed at end of article.

ty Practical Design

ing shear stresses, v_{xy} and v_{yx}, will vanish. Thus the general case of stress in three dimensions may be described by three principal stresses.

To the largest of these principal stresses, numerically, will be assigned the symbol S_1. Where we are concerned with two-dimensional analysis, S_3 will be reserved for the third-direction stress. From Equation 32*, S_3 in plane strain is given by

$$S_3=\lambda(S_1+S_2) \quad \ldots\ldots (185)$$

where λ is Poisson's ratio.

Similarly, as for the stress components, there are principal axes of strain along which the shear strain is zero (See pages 192 and 193 of Reference 6). These strain axes are coincident with the principal stress axes. Denoting the three principal strains by ϵ_1, ϵ_2 and ϵ_3 and associating them with the stresses having the same subscript, then from Equations 12, 13 and 14* the following relations exist between the principal stresses and strains

$$\epsilon_1=\frac{1}{E}\left[S_1-\lambda(S_2+S_3)\right] \quad \ldots\ldots (186)$$

$$\epsilon_2=\frac{1}{E}\left[S_2-\lambda(S_3+S_1)\right] \quad \ldots\ldots (187)$$

$$\epsilon_3=\frac{1}{E}\left[S_3-\lambda(S_1+S_2)\right] \quad \ldots\ldots (188)$$

where E is Young's modulus.

Due primarily to inadequate test data and to the lack of a satisfactory explanation of the fundamental causes, many theories of failure have been proposed. Five of them are, for one reason or another, worthy of consideration:

1. MAXIMUM STRESS THEORY assumes failure will occur when the maximum principal stress reaches the failure stress in the simple test condition, that is, denoting the equivalent failure stress by S,

$$S=S_1 \quad \ldots\ldots (189)$$

In other words, failure is considered to be independent of S_2 and S_3.

The maximum stress is often expressed as the combination of a single normal stress, S_x, with a "cross shear," v_{xy} (Reference 7, pages 263 to 269). Substituting in Equation 189 the value of S_1, obtained from Mohr's Circle diagram for this condition, *Fig.* 108, gives for this theory

$$S=\frac{1}{2}S_x\pm\sqrt{\frac{1}{4}S_x^2+(v_{xy})^2} \quad \ldots\ldots (190)$$

Equation 190 has been much used by commercial engineers for the design of short beams, shafting under combined torsion and bending, etc. It should be noted that it does not include all possible combinations of stress.

2. MAXIMUM STRAIN THEORY assumes failure will occur when the strain reaches the maximum obtained from simple test conditions. The strain in the test condition is given by $\epsilon = S/E$. Equating to Equations 186, 187 and 188,

$$S=S_1-\lambda(S_2+S_3) \quad \ldots\ldots (191a)$$

$$=S_2-\lambda(S_3+S_1) \quad \ldots\ldots (191b)$$

$$=S_3-\lambda(S_1+S_2) \quad \ldots\ldots (191c)$$

The equation to be used is, of course, the one giving the maximum value of S. This theory appears in

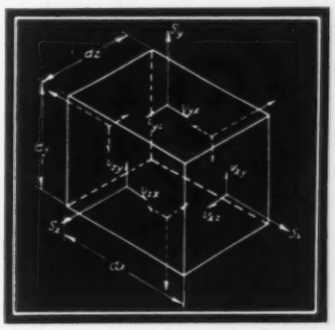


Fig. 106 — General condition of stress on elemental prism

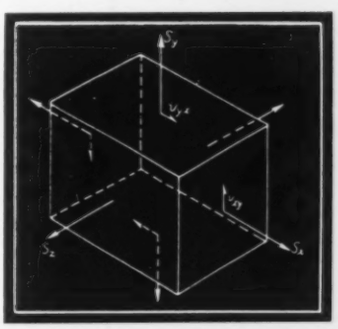


Fig. 107—Elemental prism showing general condition of two-dimensional stress

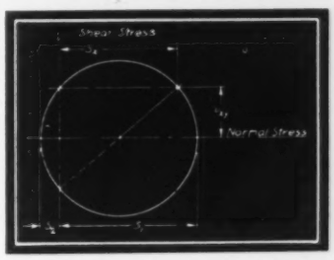


Fig. 108 — Mohr's circle diagram for a common form of the maximum stress theory of failure

* MACHINE DESIGN, March, 1941.

Merriman's (Reference 7, pages 359 to 402) as the "True Stress Theory".

3. MAXIMUM STRAIN ENERGY THEORY proposed by P. B. Haigh in 1919, is based upon the assumption that failure will occur when the stored energy per unit volume is equal to that at failure in the simple test.

Considering an unstressed elemental prism and applying first the principal stress S_1, *Fig.* 109, the *force* increases from zero to the maximum ($S_1\,dy\,dz$) and in so doing extends the prism an amount $\epsilon_1\,dx$. The energy, W_1, stored by the application of this force is equal to the average force times the deformation or

$$W_1 = \frac{1}{2}(S_1\,dy\,dz)(\epsilon_1\,dx) = \frac{1}{2}S_1\epsilon_1\,dx\,dy\,dz$$

The total energy stored by the three stresses, S_1, S_2 and S_3, is

$$W = W_1 + W_2 + W_3 = \frac{1}{2}(S_1\epsilon_1 + S_2\epsilon_2 + S_3\epsilon_3)\,dx\,dy\,dz$$

Substituting the strains from Equations 186, 187 and 188, reducing and dividing by the volume ($dx\,dy\,dz$) the energy per unit volume, w, is

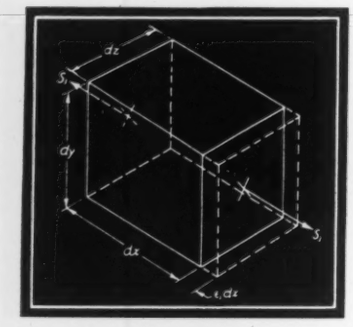


Fig. 109—Prism under simple stress

$$w = \frac{1}{2E}\left[(S_1^2 + S_2^2 + S_3^2) - 2\lambda(S_1S_2 + S_2S_3 + S_3S_1)\right] \quad \ldots\ldots\ldots\ldots (192)$$

Equating this to the unit energy of the simple test, $w = S^2/2E$, gives the failure condition

$$S^2 = (S_1^2 + S_2^2 + S_3^2) - 2\lambda(S_1S_2 + S_2S_3 + S_3S_1) \ldots . (193)$$

Equation 192 gives the total energy of deformation. Part of that energy is expended in changing the volume, the remainder in distorting the prism.

4. DISTORTION ENERGY THEORY of Von Mises and Hencky holds that the volume energy has no influence on the failure, the energy of distortion being the criterion. This apportioning of the energy may be made by dividing the stresses into parts producing volume change only, and parts producing only distortion (Reference 6, pages 137 and 138). Letting T be the average stress, that is,

$$T = \frac{1}{3}(S_1 + S_2 + S_3) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (194)$$

and subtracting it from each stress, leaves the remainders

$$S_1' = S_1 - T, \qquad S_2' = S_2 - T, \qquad S_3' = S_3 - T$$

The equal stresses, T, acting alone on the prism, *Fig.* 110, gives the condition known as a "hydrostatic head," from the similarity to the condition in a fluid. The shear stress is zero in all directions and T, therefore, produces a change in volume only, no distortion.

Sum of the residual stresses is zero, thus

$$S_1' + S_2' + S_3' = (S_1 + S_2 + S_3) - 3T = 0$$

The strains from these stresses may be obtained from Equations 186, 187 and 188, thus

$$\epsilon_1' = \frac{1}{E}\left[S_1' - \lambda(S_2' + S_3')\right], \text{etc.}$$

Their sum is also equal to zero,

$$\epsilon_1' + \epsilon_2' + \epsilon_3' = \frac{1-2\lambda}{E}(S_1' + S_2' + S_3') = 0$$

The length of a side of the prism, dx before loading, becomes $dx + \epsilon_1'\,dx = (1 + \epsilon_1')dx$ after loading. Therefore, the volume after loading is

$$[(1+\epsilon_1')dx][(1+\epsilon_2')dy][(1+\epsilon_3')dz] = (1+\epsilon_1')\times (1+\epsilon_2')(1+\epsilon_3')\,dx\,dy\,dz$$

Ignoring small quantities of a higher order

$$(1+\epsilon_1')(1+\epsilon_2')(1+\epsilon_3') = 1 + (\epsilon_1' + \epsilon_2' + \epsilon_3') = 1$$

This shows that the volume remains unchanged under these residual stresses, distortion only being produced.

The distortion energy may now be found by subtracting the volume energy from the total energy.

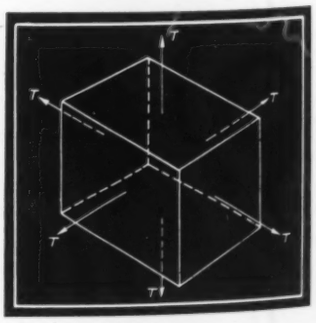


Fig. 110—Stress is equal in all directions on prism under hydrostatic head

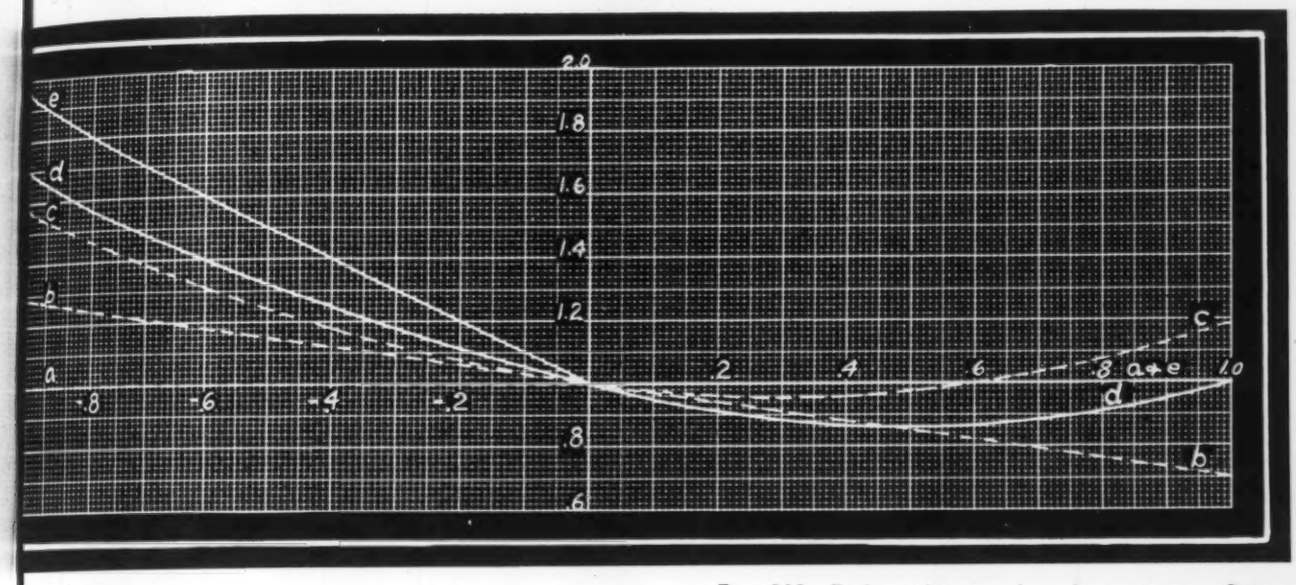


Fig. 111—Failure theories for plane stress. Curves a,b,c,d and e are, respectively, for stress, strain, energy, shear-energy, and shear theories

Replacing S_1, S_2 and S_3 in Equation 192 with T and then substituting for T from Equation 194, the volume energy per unit volume is

$$w_T = \frac{3(1-2\lambda)}{2E} T = \frac{1-2\lambda}{6E} (S_1+S_2+S_3)^2$$

Subtracting this from the total energy per unit volume in Equation 192, the distortion energy per unit volume, w', is

$$w' = \frac{1+\lambda}{6E}\left[2(S_1^2+S_2^2+S_3^2) - 2(S_1S_2 + S_2S_3 + S_3S_1)\right]$$

$$= \frac{1+\lambda}{6E}\left[(S_1-S_2)^2 + (S_2-S_3)^2 + (S_3-S_1)^2\right]$$

Distortion energy in the simple test is obtained from the above by substituting $S_2 = S_3 = 0$ and $S_1 = S$ to give

$$w' = \frac{1+\lambda}{6E}(2S^2)$$

Equating gives the following for the condition of failure in the Von Mises-Hencky theory

$$2S^2 = (S_1-S_2)^2 + (S_2-S_3)^2 + (S_3-S_1)^2 \quad \ldots\ldots (195)$$

5. MAXIMUM SHEAR STRESS THEORY assumes failure will occur when the shear stress equals that at failure in the simple test. Since the maximum shear stress is equal to one-half the principal stress difference, this criterion is expressed mathematically as

$$(S_1-S_2) \leqslant S \geqslant (S_1-S_3) \quad \ldots\ldots (196)$$

That is, both $(S_1 - S_2)$ and $(S_1 - S_3)$ must be less than S. Then $(S_2 - S_3)$ will be less than S if the above is met.

Substituting $S_3 = 0$ gives the failure theories for plane stress,

Stress: $S = S_1$ ..... (197a)

Strain: $S = S_1 - \lambda S_2$ ..... (197b)

Energy: $S = \sqrt{S_1^2 - 2\lambda S_1S_2 + S_2^2}$ ..... (197c)

Shear Energy: $S = \sqrt{S_1^2 - S_1S_2 + S_2^2}$ ..... (197d)

Shear: $S_1 - S_2 \leqslant S \geqslant S_1$ ..... (197e)

By taking λ at its average value of .30 and dividing through by S_1 we obtain the equations plotted in *Fig.* 111. The vertical coordinates in this figure give the factor by which the maximum stress is to be multiplied to obtain S for any value of the ratio of the two principal stresses. Maximum error due to the variation of λ between .25 and .35 will be at +1, being ± 7 per cent in Equation 197*b*, and $\pm 3\frac{1}{2}$ per cent in Equation 197*c*.

As an example, the plane stress equations will be applied to the cylindrical fit discussed in the May article of this series, namely, a steel hub on a steel shaft, with hub diameter twice the bore and a press fit of .001-inch per inch of diameter. From the table on page 118, also in the May issue, the tangential stress in the bore is +18,100 and this equals S_1. The pressure is 10,900 (from $Q - S_e$), giving $S_2 = -10{,}900$. S_1/S_2 then, $= -.6$ and, from *Fig.* 111, the various theories give for S/S_1 in order 1, 1.18, 1.31, 1.4 and 1.6. The "failure stress" may be as much as 60 per cent higher than S_1!

Substituting $S_3 = \lambda (S_1 + S_2)$, from Equation 185, gives the failure theories in plane strain,

Stress: $$S = S_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (198a)$$

Strain: $$S = (1+\lambda)[(1-\lambda)S_1 - \lambda S_3] \quad (198b)$$

Energy: $$S = \sqrt{(1+\lambda)[(1-\lambda)\times (S_1^2+S_2^2) - 2\lambda S_1 S_2]} \quad \ldots\ldots\ldots\ldots \quad (198c)$$

Shear Energy: $$S = \sqrt{(1-\lambda+\lambda^2)(S_1^2+S_2^2) - (1+2\lambda-2\lambda^2)S_1 S_2} \quad \ldots\ldots\ldots\ldots \quad (198d)$$

Shear: $$S_1 - S_2 \leqslant S \geqslant (1-\lambda)S_1 - \lambda S_2 \quad \ldots \quad (198e)$$

In Equation 198*e*, if $S_2 \leqslant (\lambda/1-\lambda)\ S_1$, the left side will govern, otherwise the right side rules. Taking λ at the average value of .30 and dividing through by S_1, the equations plotted in *Fig.* 112 are obtained.

Analyzing Possibility of Roller Failure

As an example of the above, the possibility of the failure of the surface of a steel roller in contact with another roller will be analyzed. From Equations 157 and 158*, $S_1 = S_2 = -q_0$ giving $S_2/S_1 = +1$. From *Fig.* 112 the five theories give for S/S_1 in order, 1, .52, 1.02, .4 and .4. In this case the maximum value is over 2½ times the minimum.

Carrying this investigation of contact failure further, the stress distribution beneath the surface is shown in *Fig.* 89* and given by Equations 157 and 158. Inserting in Equations 198, the maximum value and location of S for each theory is found as

a: $-q_0$, at the surface
b: $-.68q_0$, at $.47a$ below the surface
c: $-1.02q_0$, at the surface
d: $-.56q_0$, at $75a$ below the surface
e: $-.601q_0$, at $.786a$ below the surface.

The prediction of the risk of failure is from .56 to 1.02 and the location from 0 to .786.

As a three-dimensional problem, the *shaft* in the press fit just discussed may be considered. Here $S_1 = S_2 = -10{,}900$ and $S_3 = 0$. Now, imposing a bending load on the shaft so that $S_3 = \pm 10{,}900$ at the surface, the ratios S/S_1 on the tension side are, respectively, 1, 1.6, 1.9, 2.0 and 2.0; and on the compression side are 1, .40, 1.1, 0 and 0, from the original failure equations. Further complicating this problem is the important stress concentration usually existing at the end of the fit (Reference 8).

It is beyond the scope of this paper to enter into a detailed discussion of the experiments that have been conducted in the attempt to prove or disprove these theories. Instead, a few generalized observations will be offered.

First considering the extent of the problem, there being two variables, S_2/S_1 and S_3/S_1, a large number of tests are required. Three separate types of failure must be considered—static yield, fatigue and creep. The determination of the beginning of these failures is not easy. Even the relatively simple case of static yield is indefinite. As pointed out by H. F. Moore (Reference 9, pages 8 to 19), it may well be a matter of the sensitivity of the measuring instrument. With fatigue we have varying amplitude and direction of stress, past history of overstress, understress, cold work, corrosion, etc. (Reference 4). With the plastic condition known as creep the problems multiply. For a resume of present knowledge, and the extension of the Von Mises-Hencky theory to creep conditions, the reader is referred to a paper by Soderberg, (Reference 3) and to the references appended thereto.

Although the maximum stress theory appears today to be the least plausible, its use is so widespread that it cannot be passed over lightly. When all three stresses are equal it indicates failure when S_1 rises to the value S, which is at variance with experiments with bodies subjected to great pressure uniform over the entire surface. If Lame's limitation of the maximum tension is accepted, the failure of short columns cannot be explained. (*Figs.* 22 to 27 of Reference 4 illustrate the failure of aircraft crankshafts due to flexure combined with clamping stresses. This is a practical argument against the simple stress theory.)

Ordnance Engineers Use Strain Theory

The application by ordnance engineers of the maximum strain theory to the design of guns constitutes practical evidence in favor of this theory. Experiments with bodies under uniform pressure, for which failure is predicted when S_1 rises to $2.5S$, are not as unfavorable to this theory as to the stress theory. The evidence, however, tends to discredit it. St. Venant's theory of maximum extension, widely used on the continent, is discredited for ductile materials by tests on short columns. It would call for a compressive strength $1/\lambda$ times the tensile. Tests on brittle materials, however, fall roughly between the maximum *extension* theory and the maximum *tension*, with the evidence tending toward the maximum extension.

Haigh's strain energy theory was given considerable credence when first proposed, 1919, being in good agreement with the tests of that time. This theory is discredited also by the uniform pressure tests, indicating failure with S_1 approximately equal to S.

Recent experiments with ductile materials point to the Von Mises-Hencky theory, and most research engineers have tentatively accepted it (References 10 and 11). However, the test evidence cannot be considered as conclusive.

Shear Theory Preferred by Many

The maximum shear theory probably has the greatest acceptance with the commercial engineer. It gives results which are not, in general, at great variance with those of the Von Mises-Hencky, and are on the conservative side as may be seen from

* MACHINE DESIGN, October, 1941.

Figs. 111 and 112. It was shown by Marin (Reference 12, *Fig.* 3) that in the extreme case of shafting under combined bending and torsion the shear theory gives a shaft diameter only 5 per cent greater than that given by the shear energy theory. Experiments made by Thomas (Reference 13) on the failure of rollers confirm both the shear energy and the shear theory. The greater simplicity of the latter will make it attractive to the commercial engineer.

Metallography Gives Clues

H. F. Moore (Reference 11) has pointed out that probably the best place to look for a clue is in metallography. In conjunction with Tibor Ver (Reference 14) he gives some excellent micrographs of slip lines due to repeated stress, evidence favoring the shear theory, although conceivably consonant with the distortion energy hypothesis. This thought is also confirmed by Gough (Reference 15). The reader is referred to Sauveur (Reference 16, pages 1 to 31) for discussion of the atomic and crystalline structure of metals.

It is logical to suppose a relationship between failure strength and hardness. The reader is again referred to Sauveur (Reference 16, pages 265 to 284) for a discussion of some of the theories of hardening, and to the Jeffries-Archer slip interference theory (Reference 19). A novel viewpoint, that imperfections of the lattice structure of a metal cause it to be soft, the perfect metal being intensely hard, is presented in Reference 17. Sauveur (Reference 18, page 17) made tests of single crystals under torsion. Yielding occurred due to successive step-like slipping believed to be due to successive shear failure along atomic planes.

If we may consider that failure occurs when the atomic spacing is too greatly increased, or when the space lattice is too much distorted, we will have a theory fitting fairly well with the observed facts for both brittle and ductile materials; and one that would explain why some materials will under some stress conditions, fail with a brittle fracture, and under other conditions with a ductile fracture (Reference 3, page 4; Reference 1, page 4 to 7 and Reference 2, page 4). On this basis the combined use of the maximum extension version of the strain theory, together with the shear theory, would be advocated. Failure could be expected whenever either criterion is met. Tests would then be needed that would give a direct measure of the cohesive and the lattice strengths. Satisfactory tests of this sort have not as yet been offered. In the meantime the writer recommends the maximum extension as a working hypothesis for materials generally considered "brittle" and the shear theory for those classed as "ductile".

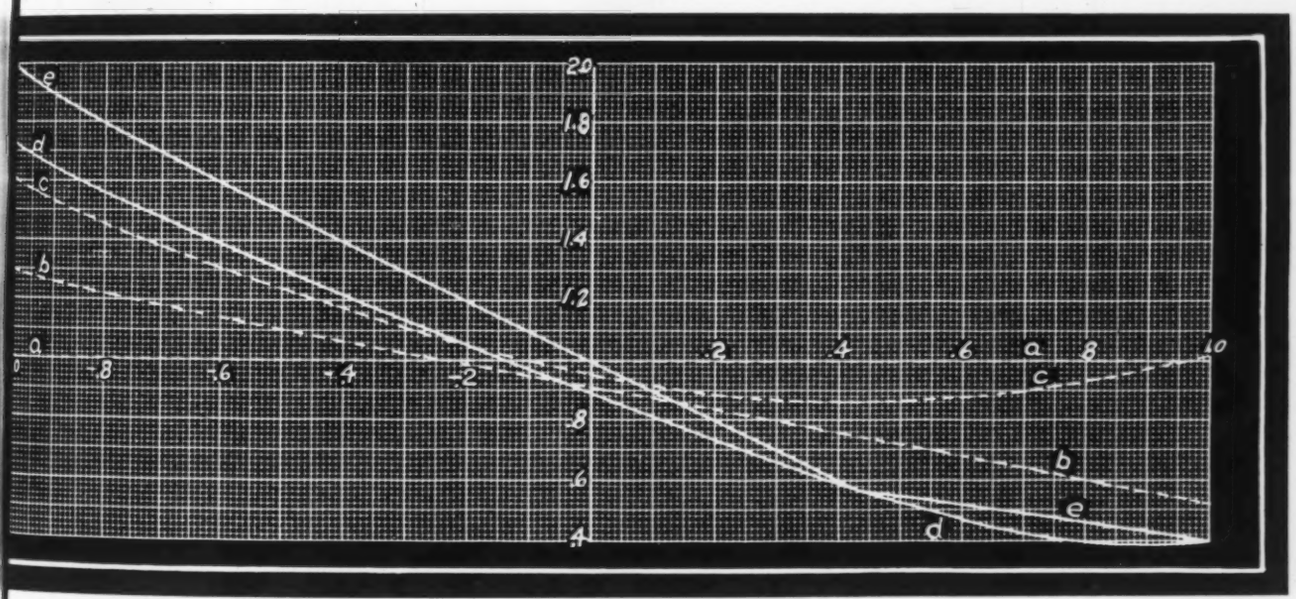


Fig. 112—Failure theories for pla n strain. Curves correspond to those for Fig. 111

This concludes the series on elastic theory. The primary purpose of these discussions has been to arouse the interest of the engineer to the far-reaching commercial applications of higher stress analysis. The day for guessing is past and the concern adhering to such practices is doomed to failure in the intense industrial struggle that is bound to follow the latest armed conflict. No longer will half-measures suffice, as the expense of experiments in the field and the luxury of "factors of ignorance" can no longer be tolerated. Moreover, as industrializ-

(*Continued on Page* 134)

Deep Drawing May Answ

By Kenneth D. Moslander

DRAWING operations are performed in that portion of a material's stress-strain curve known as the "plastic" range. The lower limit of this range, which must be exceeded, is the elastic limit. The upper limit, which must not be exceeded, is the ultimate strength.

In regard to this upper limit, however, a distinction should be made between the conventional ultimate stress calculated by dividing the load at rupture by the original cross-sectional area of the specimen and the true ultimate calculated by dividing the same load by the area of the reduced section at the point of fracture. It is not unusual for the latter stress to exceed the former by more than one hundred per cent.

Hence in considering a material for a drawn part the conventional ultimate stress does not serve as a satisfactory criterion of drawing properties or plasticity. Per cent reduction in area of a tensile specimen stressed to fracture is more nearly a true measure. Also commonly used as a measure of the true ultimate is the indentation resulting from a brinell hardness test. This test—since it requires no elaborate specimen preparation, can be accomplished quickly and conveniently and lends itself to simple measurement—is often preferred to the reduction in area test.

Lower limit of the plastic range is ordinarily available as the stress at the elastic limit. In some cases a scleroscope reading is used as a measure of elastic limit.

Since all drawing operations occur between these two limits it is apparent that the greater the stress range between the elastic limit and the true ultimate, the greater is the possible depth of draw in one operation. The essential similarity between drawing and forging is thus evident. Both processes utilize the plastic range of the material but, in the latter case, this range is greatly increased by heating the blank. Drawing is, therefore, the more critical of the two.

Annealing Restores Physical Properties

In a drawing operation, after each differential of draw depth the material has a new group of physical properties resulting from the cold working. Elastic limit, hardness, yield point and, to a lesser extent, ultimate strength are increased and plastic range is thereby decreased. Residual stresses in the material contribute to the phenomenon of "spring-back." In drawn parts this results in a final shape differing from that of the punch and die in which the part was formed. Because of the several variables (all of which change constantly during a drawing operation) on which spring-back depends, it may be calculated empirically for only a few simple shapes. Ordinarily the experience of the stampings producer on analogous parts can be relied upon to over-

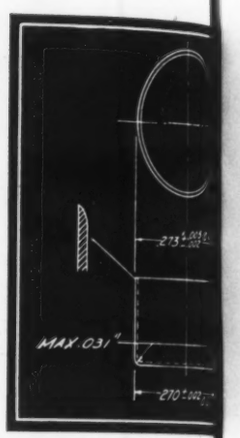


Fig. 1—Made of nickel .005-inch thick, this cup represents the simplest of drawn parts

Fig. 2 — Trimming of open end results in characteristic edge radius of nickel-plated drawn copper shell

Fig. 3—Close tolerance on inside diameter is attained so part can accommodate mica disk

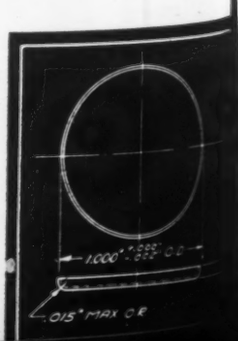


Fig. 4 — In shallow drawing operations care should be exercised to avoid overstressing stock along edge of die

Your Production Problems

come this effect so that parts are obtainable within the necessary tolerances.

Total depth of draw is not limited by the plastic range; only is the depth in one operation so restricted. Annealing may be resorted to after a draw to restore, almost entirely, the original plasticity. However, such annealing operations are expensive and the design should be scrutinized carefully in consultation with the stampings representative with a view toward their elimination when possible.

Cold Rolling Limits Draw Depth

For example, a material cold rolled to spring temper may have its plasticity largely destroyed. Annealing will restore it to the unstrained state. A drawing operation may again destroy it after which annealing may again be resorted to.

Neglecting certain finishing operations such as trimming or ironing, certain approximations may be stated which are of assistance to the designer in visualizing the practicability of his design. In a drawn part, excluding a usually negligible stretching, the surface area of material in the finished part will be essentially equal to that of the blank. Also, the average metal thickness will be equal to the blank thickness and, obviously, the total weight or volume remains unchanged.

Flow of metal results from internal tensile or compressive stresses imposed in the material by the forming tools. The former results in thinning the section; the latter in thickening it. The vector summation of each is identical. Further, these internal stresses act parallel to the surface of the material being formed.

Many of the rules discussed in the November article of this series in connection with blanking, forming, piercing, curling, etc., apply even more emphatically to drawing. For example, corner radii should be at least equal to the stock thickness, maximum permissible tolerances should be permitted on dimensions, surface condition should be specified only where essential, etc.

In addition, certain "rules of thumb" apply specifically to drawing operations. In the case of rectangular parts the radius of the corner exercises a controlling function on the possible depth of draw. This radius should be left as large as possible and should, in no case, be less than one-fourth of the draw depth.

As a general rule for cylindrical shells, the depth of draw in deep-drawing steel should not exceed the diameter. As a corollary, the depth must be equal to or less than one-third the diameter of the blank. Hence, if a top flange is necessary, a further decrease in depth is essential to avoid overstressing.

When a high degree of accuracy is required in metal thickness and surface finish it is possible to comply with these specifications by means of ironing operations. The practical limitations on the extent to which the metal may be so upset is from .002 to .004-inch. In fact, much better finish may be obtained if the amount of upsetting is considerably less.

What happens to a metal in the course of a drawing operation can perhaps be best visualized by what, under similar circumstances, would happen to a very plastic material such as, for example, modeling clay. If a sheet of such clay is laid across the top of a cup (die) and then pressed evenly into it so that the clay conforms to the inside shape of the cup, various phenomena analogous to those in drawing metal will be observed.

First, wrinkles will tend to form in the material as it passes over the edge of the cup. This is the natural consequence of progressively reducing those concentric circular elements which, in the original blank, lay outside the edge of the cup. Wrinkles indicate compression stresses in the material.

In metal drawing operations such wrinkles are prevented from forming by holding pads, ironing dies, beading and other devices. Compression stresses exceeding the yield point nevertheless are present and result in a thickening of the metal in this section.

Induce Stress Concentration

As the material passes over the lip of the cup tensile stresses are imposed by the punch in a direction parallel to the punch travel. Such stresses may, and usually do, exceed the yield point; the consequent attenuation results in a reduction of metal thickness.

It is of interest to note that if the instrument used to simulate a punch has a spherical end surface, breaking-through or tearing of the sheet will occur much sooner in the draw than if the end or bottom of the punch were flat with moderate radii. Obviously this is the limiting case of corner radius where this radius is equal to

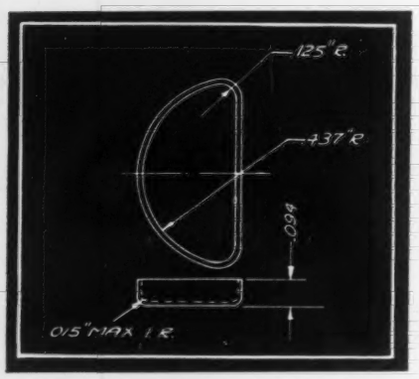


Fig. 5—For irregular or rectangular shapes the corner radius should be at least one-fourth the draw depth to avoid overstressing

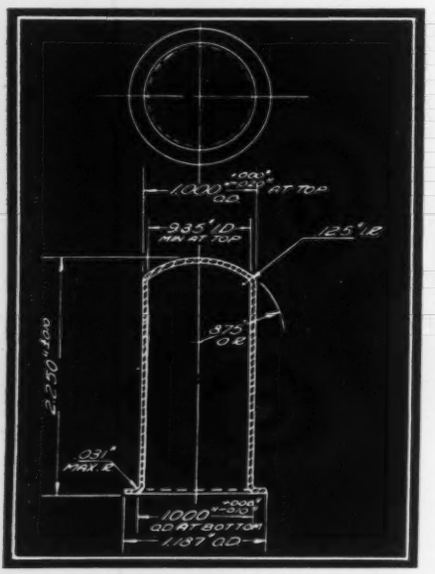


Fig. 6—Round bottoms of shells introduce more severe stressing of material than flat-bottom shells with moderate corner radii

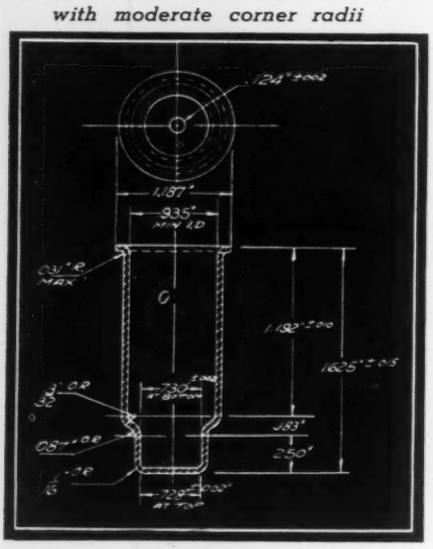


Fig. 7—Liberal tolerances of plus or minus fifteen thousandths contribute to the economy of deep drawn metal parts

half the diameter of the shell. However, failure does not occur because the radius is large but because the depth of draw has been materially increased by the large radius. Also, the small contact area between the punch and the blank produces high stress concentrations which may exceed the ultimate.

Illustrated in *Fig.* 1 is practically the simplest type of drawn cup. It serves to indicate the approximate ratio of depth to diameter which can be commercially produced in large quantities from such materials as nickel alloy or steel without an excessive number of rejects due to metal failure as a result of overstressing. The cup is produced three-up in automatic compound dies. It will be noted that ample tolerance on both the outside diameter and the depth is provided since these dimensions are not critical. If the design had specified a closer tolerance on the depth of, for example, plus or minus .002-inch, this would have necessitated a final trim, possibly in a second operation, thereby resulting in higher cost. A slightly larger radius at the bottom corners than the specified .031-inch would be desirable. Stress concentration at the corners could be reduced, thereby permitting faster operation of the presses with a consequent reduction in cost.

Another factor influencing cost which is often overlooked is the slight taper from the top to the bottom of the cup which is allowed to facilitate stripping the drawn cups from the punch. Such taper can be allowed for by specifying a smaller bottom diameter than top. If identical top and bottom diameters are specified taper can be provided for by indicating tolerances in the plus direction for the upper open end and in the minus direction for the lower.

Cost Varies Inversely With Draw Depth

It will be observed in the case of this cup that the depth of draw is less than the diameter. This is reconcilable with the previous statement regarding allowable draw depth by the fact that this cup is an extremely high production part. The deeper the draw, the greater are the stresses imposed in the work. Naturally this leads to increased wear on the tools and a shortening of their life before re-grinding becomes necessary.

Where, as in this case, production speed is a vital consideration it is desirable to use as high a press speed as possible. Unfortunately the highest speed presses introduce the most severe working conditions on the metal. The following presses, in general use, are listed in the descending order of speed of operation: Crank, toggle, rack and pinion and hydraulic.

Crank presses have a punch travel which is essentially harmonic. Since usually only the lower half of the stroke is used it is evident that initial contact of the punch with the work may occur at about the highest speed. In the toggle type press the speed again is a maximum at the point of contact, falling off to zero at the end of the stroke. Exactly the reverse speed-displacement characteristic would be more desirable from the standpoint of deep drawing operations. The rack and pinion press is typified by a constant velocity of the ram or punch. This is more satisfactory from the standpoint of drawing operations but, if the rack and pinion teeth are not accurately formed, vibrations may be transmitted to the punch which will have an unfavorable effect upon the drawn parts.

Hydraulic presses permit great flexibility of control. Ram speed at the point of contact with the work may be maintained at a minimum. Acceleration to an optimum drawing speed may be gradual and the velocity of the ram may be tapered off as the limit of draw depth is approached. However, while such presses

usually are used for large parts such as airplane wing and fuselage sections, automobile body parts, etc., because of their speed limitation they are not so frequently used for the production of small machine parts, despite the fact that with them a material increase in the depth of draw in a single operation may be achieved.

Only One Shell Diameter Specified

A somewhat more complicated drawn part is illustrated in *Fig.* 2. It is valuable to this discussion because it illustrates the manner in which the metal thickness is allowed, within reason, to vary. Since the inside diameter of the large upper end is critical this dimension alone is specified. However, the outside diameter of the smaller lower section is critical and hence it only is dimensioned. Thus the outside diameter of the upper section and the inside diameter of the lower section are allowed to follow the metal thickness. If this were not the case expensive ironing operations would have to be carried out in order to maintain metal thickness which might, as far as the utility of the part is concerned, be unnecessary.

The auxiliary view shows the small curvature of the upper edge of the flange which results from the press trimming operation. If such a curvature were objectionable square edges could be specified but only with the realization of consequent cost increase. Attention is also called to the close tolerances on the .938-inch dimension of plus or minus .005-inch. Also the .364-inch inside radius is sharp. If somewhat larger tolerances and a longer radius were permissible the multiple operations by which this part was formed might be reduced, resulting in decreased cost.

In connection with *Fig.* 3 the combination of close tolerances and the irregular though symmetrical shape leads to appreciable tool maintenance expense which might be avoided even if the tolerances, only, were somewhat relaxed. This same comment applies in particular to the .015-inch maximum radius. If 1/32-inch were allowed for this radius a more economical part would result.

A small mica disk .330-inch in diameter is inserted in the .332-inch inside diameter recess. Hence this dimension and tolerance are critical and are so specified. Similarly .035-inch diameter wires are seated in the .036-inch inside diameter grooves and are welded to the groove

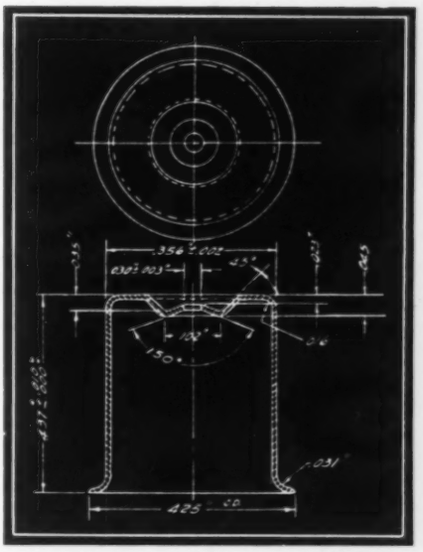


Fig. 8—To prevent deformation in the drawing operation bottom holes are pierced after forming

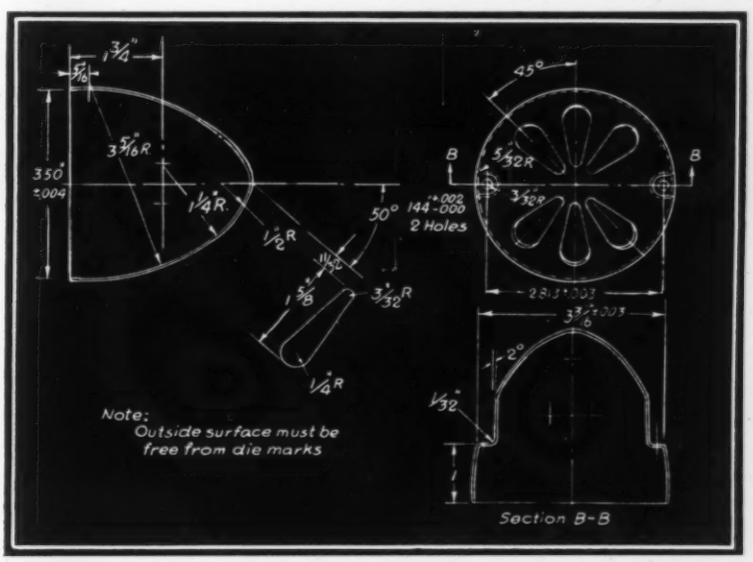


Fig. 9—Use of cold-rolled steel for drawn parts limits the draw depth in a single operation, often necessitating annealing

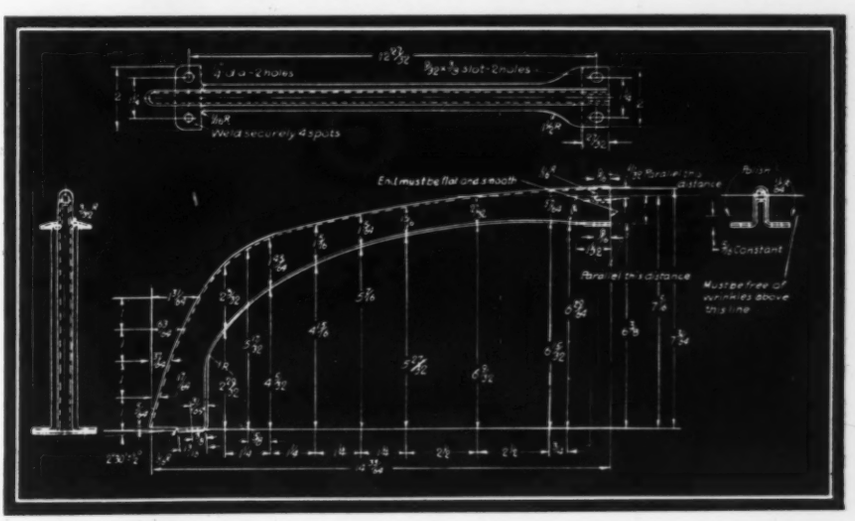


Fig. 10—Tendency toward overstressing and wrinkling in the knee of the channel section makes this part difficult to draw

walls by spot welding from the outside.

The simple, shallow draw shown in *Fig.* 4 is of a type in which dimensions can be closely held without adding excessively to the cost of the part. If such shallow draws are to be made with a flange however, serious complications often result. This is due to the fact that only a small angular displacement of the material with respect to the original blank is used. In consequence the component of punch force in the direction of radial elements of the material results in extremely high stresses.

Corner radii are the chief points of interest in connection with *Fig.* 5. As pointed out previously such radii should always exceed one-fourth the total draw depth. In this case the .125-inch radius is sufficiently large to avoid trouble due to wrinkling or overstressing at the drawn corners.

Metal radio tube shells are illustrated in *Figs.* 6 and 7. In such high production parts as these it is desirable to allow liberal tolerances on the length and outside diameters. Tool costs would be appreciably reduced if the sharp corner radii were not necessary. As stated in connection with *Fig.* 1, rounded corners ordinarily result from the press trimming of the open edges of these parts.

With reference to *Fig.* 8 an important design factor affecting cost may be stated in connection with the pierced hole at the bottom of the shell. Except in extremely rare instances where adequate holding means are provided, because of the contour of the bottom of the part, such holes must be pierced after the drawing operation. The reason for this is that, if pierced in the blank, the flow of metal from under the bottom of the punch around the corner of the punch and into the wall of the part is not always symmetrical. Hence the hole usually will be pulled out of shape.

Holes Are Stress-Raisers

Further, such a hole always tends to act as a stress-raiser in aggravating stress concentration conditions in the bottom of the shell. This factor is of especially vital importance when the shell bottom is not flat but curved as shown in *Fig.* 6.

Condition of high stress concentration resulting from the drawing of a semi-pointed nose on a shell is most severe in the end cap illustrated in *Fig.* 9. It will be recalled in connection with the discussion of *Fig.* 6 that the curved end limited the possible depth of draw and added appreciably to the risk of metal failure in the drawing operation. In *Fig.* 9 this condition is even more severe. Further, since the part is specified to be made of cold-rolled steel .019-inch in thickness an anneal is required between the two separate drawing operations.

One reason for the anneal has already been stated. That is the pointed end of the shell. A second reason is the specification of cold-rolled material. A considerable amount of the plastic range is destroyed by the cold working incidental to the production of cold-rolled sheet. Hence if parts are to be drawn from this material the allowable depth of draw is considerably reduced. A third reason is the thinness of the material, only .019-inch thick. With material as thin as this even a slight reduction around the point of the punch greatly weakens the stock and increases the possibility of failure by tearing. If the stock thickness specified had been .025 to .031-inch in thickness the die cost would have been materially decreased and the expensive annealing operation might have been obviated. Because the 1/32-inch shoulder radius is specified to be formed in

(*Continued on Page* 138)

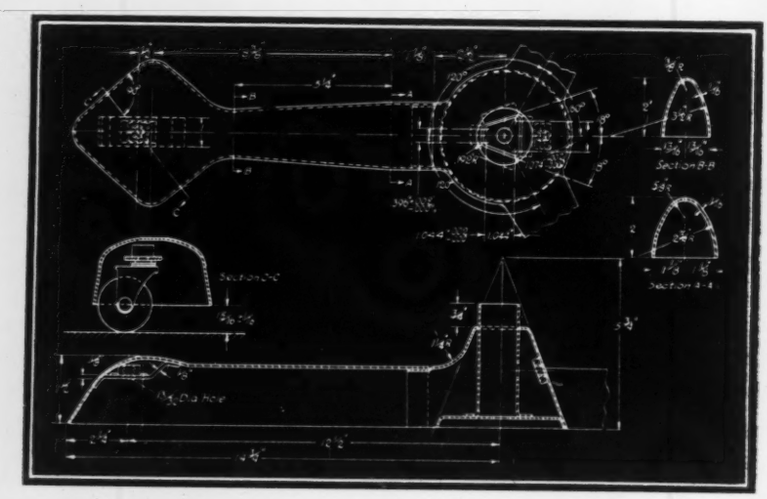


Fig. 11—Machine standard composed entirely of drawn parts is assembled by spot and gas welding

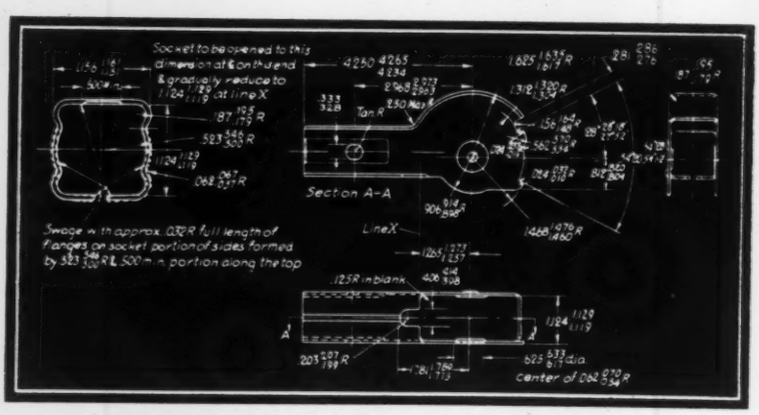

Socket to be opened to this dimension at 6 on thumb end & gradually reduced to at line X
Section A-A
Line X
.125R in blank
Swage in th approx. .032R full length of flanges on socket portion of sides formed by 323 R & .500 in. portion along the top
Center of .062 R

Fig. 12—Careful specifications of dimension, contour and finish make this a model drawing for a stamped part

Metals Industries Are Girt for War

NEW aids to national defense production was the emphatic keynote of the 23rd annual convention of the American Society for Metals held October 20 to 24 in Philadelphia. At the time of the show last year in Cleveland industry was only just awakening to the urgency of the defense effort. However, at this year's show, everywhere the visitor turned were constant reminders of the fact that all-out efforts now are definitely being made to gear up production in preparation for war.

Guns, tanks and cartridge cases illustrated at the right are typical of the extensive armament display which included Allison and Lycoming airplane engines as well as Wright and Pratt and Whitney of the radial type, bombproof shelters, the vaunted Sperry bombsight, machine guns and other small arms. In fact, large sections of the exhibitions resembled more a military armory than an exhibit of the metals industry.

Both from the standpoint of space occupied and the total of 335 exhibitors this show was the largest in history, despite the fact that delivery commitments precluded the exhibition of many large machines. As an adjunct to the show were 79 scheduled technical meetings devoted largely to the conservation and substitution of engineering materials and parts vital to defense.

The manner in which pioneering engineering advances are being co-ordinated with the defense effort is well exemplified by the recognition given to the advantages of the high-speed spectrograph and the electron microscope. These instruments which only a few months ago were in the development stage have been requisitioned by the emergency.

Functioning of industry under a system of free enterprise was contrasted spectacularly to that of totalitarianism in these critical times. In the latter case there is evidence to support the opinion that, in Germany, engineering advances were frozen as of the dawn of the emergency and all engineering energies were devoted to production. In this country engineering research and development proceeds and the fruits of these labors are immediately mobilized to expedite the defense effort. For example, advances in the design for, and technique of, casting and welding are being taken advantage of in such ordnance equipment as armored tanks. On the other hand examination of captured German tanks indicates by the inferiority of the welds and the absence of castings that that country has not kept abreast of technical developments along these lines for the last 15 years. The recent metals show gives renewed confidence that in this war of machines the best machines will decide the issue, the result being a monument to American engineering.

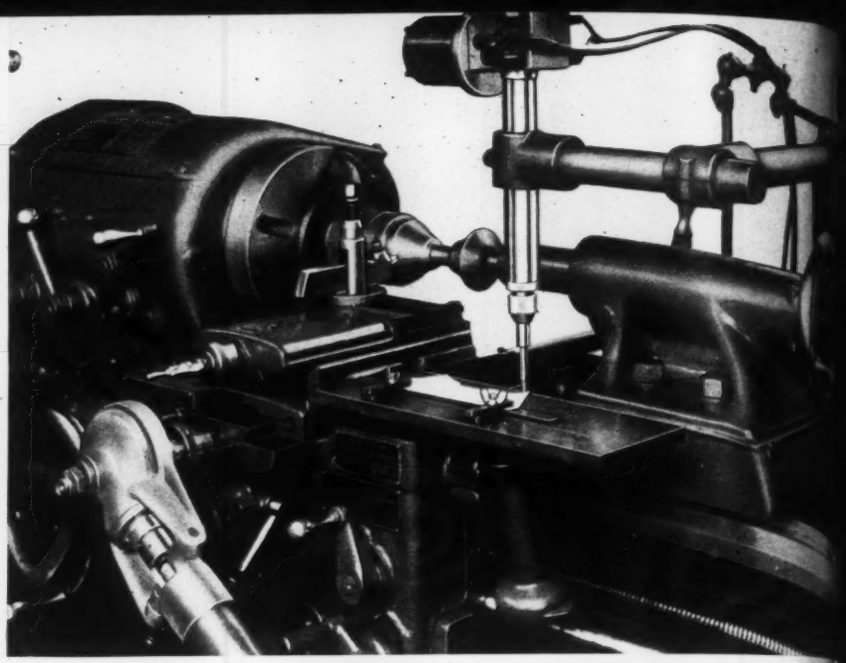
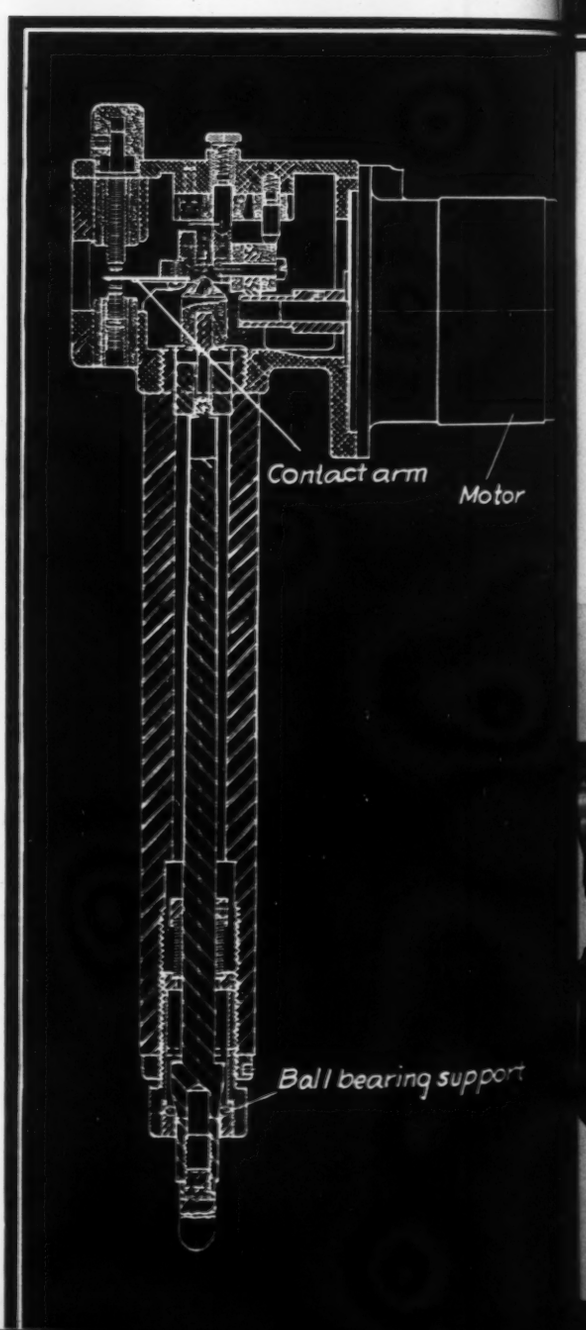


Fig. 1—Duplicator on engine lathe automatically machines workpiece, being controlled by stylus, templet and electro-hydraulic unit

Fig. 2—Below—Sectional drawing of tracer shows movable arm and ball-bearing joint which transmits any movement of the stylus as a vertical movement of the contact arm. This arm controls through solenoids the direction of rotation of a fluid motor

Electro-Hydraulic Unit Gives Sensitive Control



MEANS to increase production, eliminate the necessity for highly skilled help or reduce the demand for special automatic production equipment is of particular interest in these critical times. One such device, manufactured by the Detroit Universal Duplicator Co., is illustrated in *Fig.* 1. Through the use of a solenoid-controlled hydraulic motor, this simple design accurately governs a machine's operation by pressure of a tracer finger on a templet or master cam.

Accuracy plus speed of operation are essential in a unit of this kind. Ease of operation also is important, to allow rapid operator training. These features have been adequately provided for in the design, and standard component parts have been specified, insofar as possible, to permit quick servicing. Reference to *Fig.* 2 shows how any horizontal or vertical movement of the stylus resolves itself into a vertical movement of its shaft through a ball bearing support. Adjustment of a contact arm is so made that upward movement of the

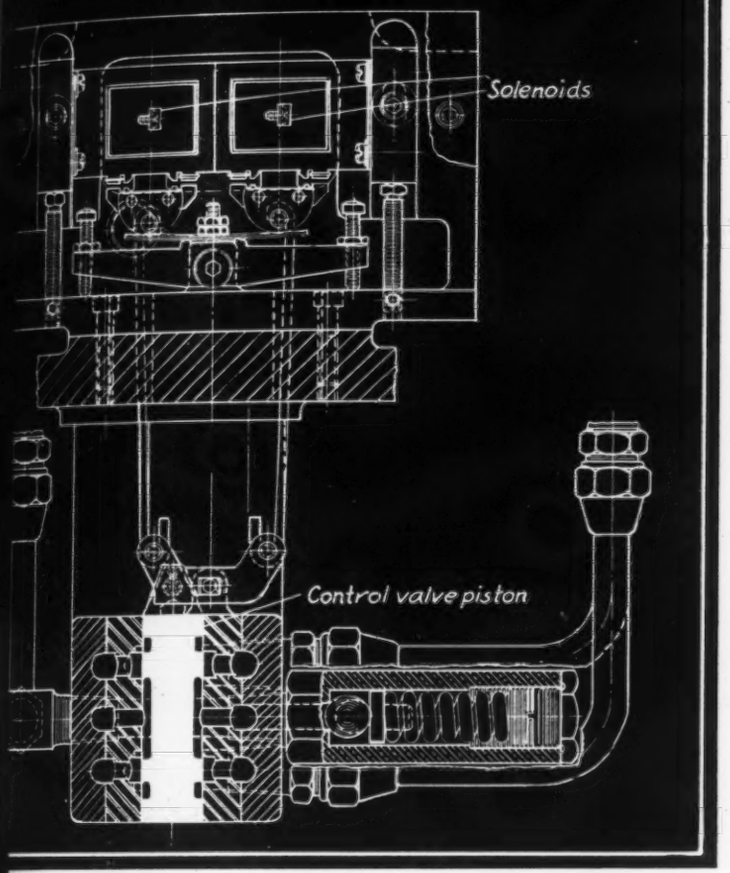


Fig. 3—Two solenoids, each connected with its respective contact point in the tracer, are held in continuous movement by interrupted contacts. Definite movement of stylus causes the valve to admit fluid to hydraulic motor, driving it in the required direction of rotation

arm provides contact with an upper point and downward movement causes contact with a lower.

This is not, however, a continuous contact but rather a continuously interrupted contact that opens even before the shaft is lowered. A fractional horsepower motor, 1800 revolutions per minute, drives a cam which places the contact point in continuous high-speed vibration.

Each of the two points is connected with a solenoid, *Fig.* 3, controlling the position of a plunger valve. Raising the plunger admits fluid supplied to the valve through a port to drive the hydraulic motor in one direction. When the stylus causes a majority of contacts to be made at the lower point, which is connected with the other solenoid, the plunger is lowered and the hydraulic motor reverses.

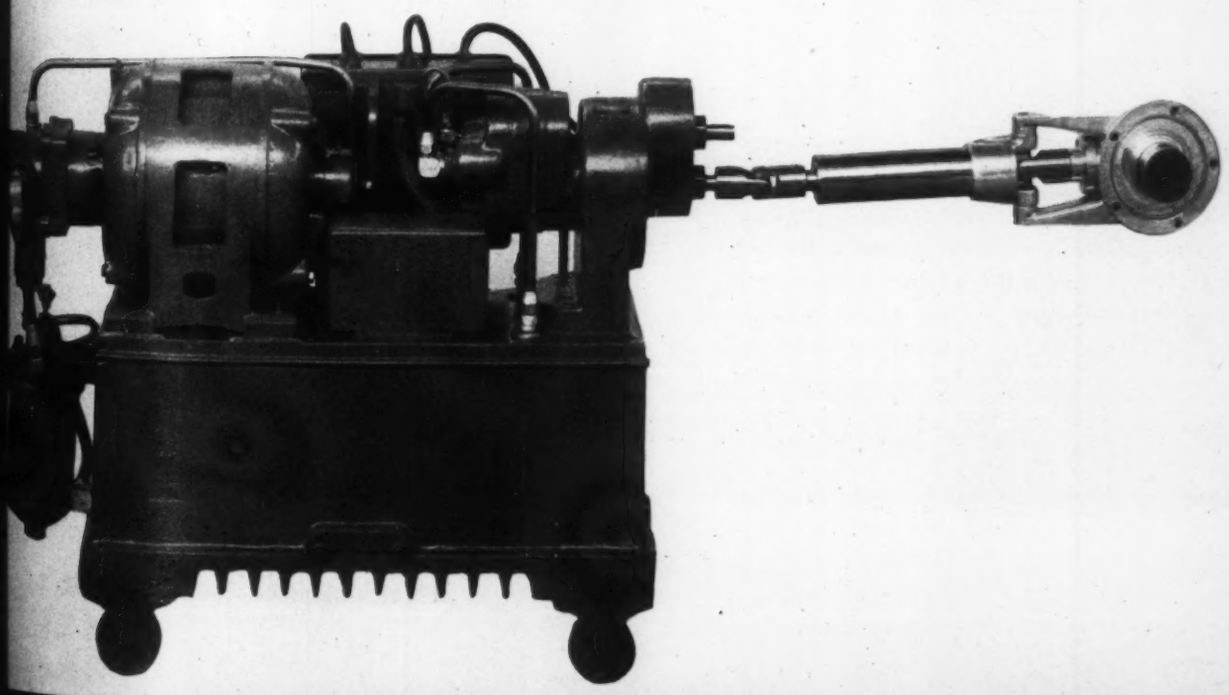
If there is no movement of the tracer arm the solenoids are at rest except for the rapid make and break of the contacts. A spring tends to bring the solenoids to rest, but some of this movement is transmitted to the hydraulic motor through the constant, though slight, movement of the valve plunger. This continual movement is essential in order that the duplicator will not "lag" but will be sensitive to the smallest tracer movements.

When insufficient energization of the solenoids causes no movement in the valve, the fluid from the pump passes through a space between the plunger ring shoulders and both ports. This balances the pressure in both hydraulic motor lines, keeping the motor at rest. Excess fluid returns to the reservoir.

Shown in *Fig.* 4 is the control unit, consisting of the solenoids, an oil reservoir, which forms the base, an electric motor, hydraulic pump, hydraulic valve, hydraulic motor, switch box, oil filter, etc. Cast fins on the bottom of the unit aid in cooling the oil. Output of the hydraulic motor is limited by a friction device on a gearbox through which the driveshaft operates the tool feed. To permit placing the unit conveniently, each end of the driveshaft has universal joints.

When duplicating extremely steep-walled work on lathes and milling machines, a solenoid-actuated clutch operates automatically from the tracer contact, braking the transverse feed in inverse ratio to the speed of the tracing finger. Thus the proper relative speeds of both the carriage travel and the tranverse feed prevent cutter from digging.

Fig. 4—Portable control unit comprises motor, hydraulic motor, solenoids, oil filter and oil reservoir



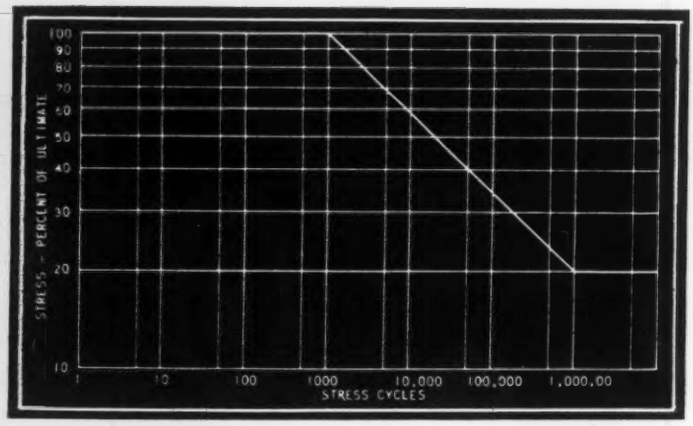


Fig. 1—Plotting the conventional S-N curve on logarithmic coordinates provides a sharp break at the finite stress range limits

Temper Th

By J. O. Almen

Head, Mechanical Engineering Dept.
General Motors Research Laboratories

EVERY engineer is taught how to solve for stress in loaded members and, after becoming reasonably proficient at stress problems, he is advised that it is a pretty good idea to assume his answers are from 50 to 90 per cent wrong. Of course, he is not advised in these words or with this emphasis. More elegantly, a fifty per cent probable error becomes a factor of safety of two, a ninety per cent probable error becomes a factor of safety of ten, and thus the greater the doubt the safer we feel. The fact is that no means are yet available for reliable determination of stresses in dynamically loaded, highly stressed, machine parts. . . . .

Photoelastic analyses can be made to reveal major stress patterns but do not always provide useful quantitative values of stress. Extensometer readings, brittle lacquers, etc., likewise can show major stress patterns but may fail to provide reliable quantitative stress values. Even if true stress could be found, the permissible working stress cannot be judged entirely from fatigue tests on laboratory specimens. . . . .

Experience Supersedes Calculations

In the design of light machines where safety cannot be sought in oversize parts but must be obtained by designing as exactly as possible to the required strength, we frequently find that an experienced designer can estimate the required dimensions of a part more accurately than they can be calculated by textbook methods. Nevertheless, stress calculations must be made as first approximations in the design of parts for a new machine. Such calculations usually follow conventional methods but instead of applying arbitrary factors of safety we are guided by accumulated experience in the form of limiting stresses which vary with the kind of machine part that is being considered.

For example, automobile crankshafts may be stressed, by calculation, to 20,000 pounds per square inch; the connecting rods will tolerate calculated stresses of 40,000 pounds per square inch; valve springs do somewhat better, calculating to be approximately 90,000 pounds per square inch; disk clutch springs are good for 180,000 while other forms of clutch springs may safely carry 600,000 pounds per square inch calculated stress. These few examples are given to illustrate that calculated stresses are, in themselves, meaningless and are of value only when interpreted in the light of practical experience. . . .

Photoelastic and extensometer readings are measures of elasticity in which the changes in dimensions are the statistical average of all of the material involved in the measurement. Fatigue tests provide a strength measure of the weakest portion of the material involved, usually at the surface, even though it be submicroscopic in size. Obviously, agreement cannot be expected between fatigue measures of stress and the stress readings obtained from elastic measurements, either tensile, compressive or bending.

This should not be construed to mean that stress measuring devices should not be used. Photoelastic tests are particularly useful to demonstrate, qualitatively, the increase in stress at fillets, notches, holes and other section changes. Extensometer measurements have similar though somewhat broader utility since readings may be

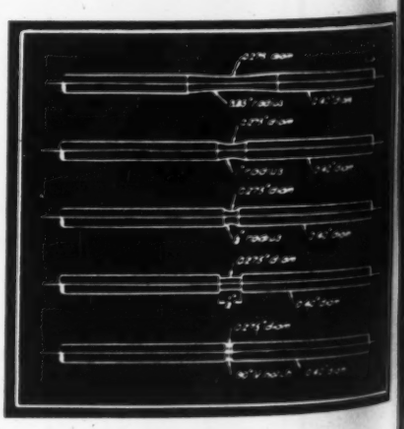


Fig. 2—Fatigue test specimens are designed for varying degrees of severity

with Experience

taken from actual machine parts to show the effect of section changes. These readings can sometimes point the way to alterations in design for more uniform stress distribution, providing that the manner of load application in service is known and not assumed. However, they should be regarded as qualitative and not as quantitative measures of stress when applied to cyclically stressed parts.[1]

NOT deprecating analytical stress calculations but placing a timely emphasis on the value of empirical fatigue data, this article is abstracted from a paper presented before the recent semi-annual meeting of the American Gear Manufacturers association. Close correspondence of such fatigue tests with actual service conditions makes them invaluable where highly stressed, light-weight parts are required in machines

Fatigue test data as reported by many books and papers are not directly applicable to the design of light weight, high output machine parts because, with few exceptions, they assume: (1) That stress can be calculated; (2) that a machine part must be stressed below the fatigue endurance limit to be successful; (3) that laboratory test specimens are representative of a material when that material is used in a machine part; and (4) that a representative fatigue curve can be constructed from a dozen or less specimens.

The graphs, or *S-N* diagrams, as usually used to present fatigue data, show stress plotted on the vertical axis and stress repetition or cycles plotted on the horizontal axis. These graphs are variously constructed on linear coordinates, logarithmic coordinates or on linear ordinates and logarithmic abscissa. . . . The second form, less frequently used, is preferred for this paper because, as shown in *Fig.* 1, the fatigue curve appears substantially as a straight line when plot-

[1] O. J. Horger and T. V. Bookwalter, *Metal Progress*, Feb. 1941.

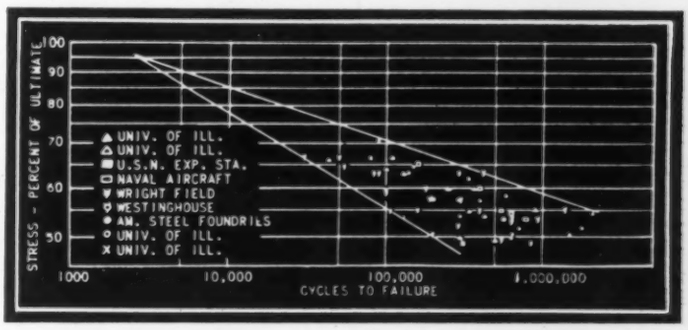


Fig. 5—Phenomenon of convergence is again demonstrated by independent tests on SAE 4340

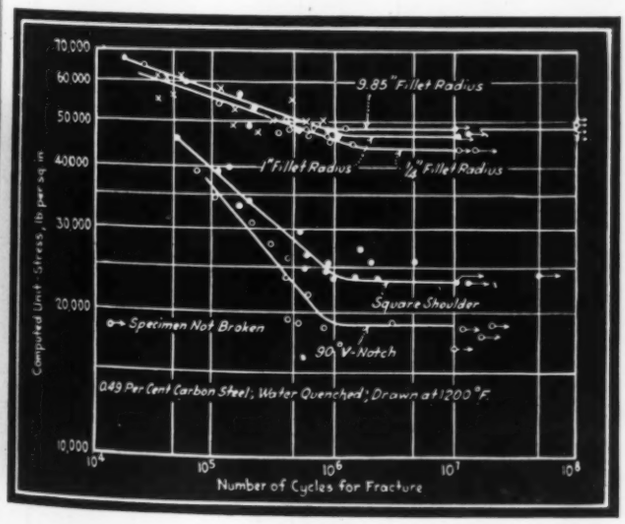
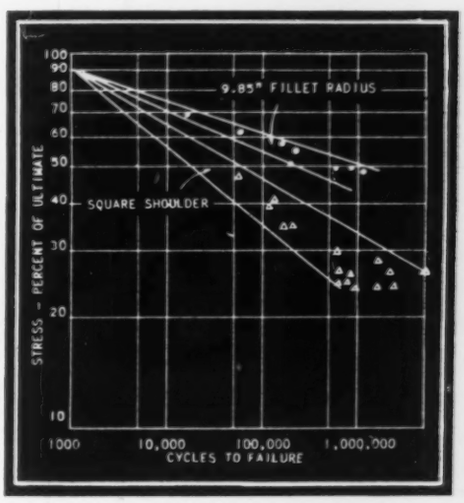


Fig. 3 — Left — Plot of data obtained by testing specimens in Fig. 2 affords a comparison of the effect of contour changes

Fig. 4 — Right — Convergence of the scatter band of tests indicated by Fig. 3 occurs at the ultimate strength of the material



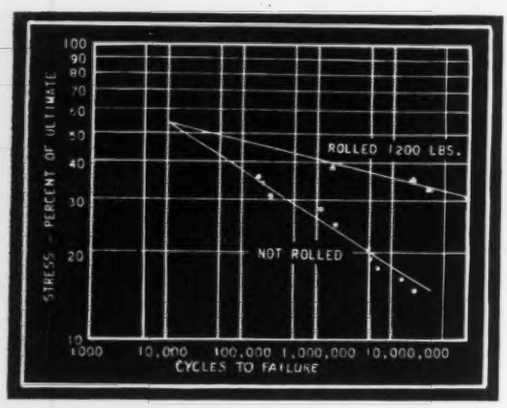


Fig. 6—Internal stresses induced by cold rolling reduce fatigue strength

ted on logarithmic coordinates. . . .

The assumption that machine parts must be stressed below the fatigue endurance limit has led most investigators in this field to test their specimens at stresses near this limit; that is, at stresses so low that the specimen will endure for an infinite number of stress repetitions without failure. There is, therefore, very little data from which to construct the characteristic curve of failure of specimens in the finite life region of fatigue; that is, that part of the diagram lying between one stress cycle and one million stress cycles. Many machine parts are operated at maximum stresses above the fatigue endurance limit and failure, when failure occurs in such parts, is due to a relatively small number of stress cycles at maximum stress. . . .

Life requirements are fixed by the abusive type of user and are sufficiently high so that failure rarely occurs during the lifetime of the automobile except in the case of an accident. Obviously, to design such parts for infinite life at maximum stress would be economically wasteful.

The preferred laboratory fatigue test specimen is carefully prepared to avoid all surface imperfections, abrupt section changes, internal stresses, etc. . . . There can be no objection to this procedure as it refers to the test specimens but the data thus obtained can have little bearing on the fatigue characteristics of machine parts made from the same material and given the same heat treatment in which surface irregularities, abrupt changes in section and internal stresses are almost always present.

Many laboratory fatigue tests have been reported from specimens having varying degrees of surface roughness and various notch forms. These data are important in that they show different characteristics from the smooth-surfaced uniform section specimens. *Fig.* 2 shows a series of fatigue specimens used by Moore and Kommers[2] to determine the effect on fatigue of varying degrees of stress concentration. The resulting fatigue curves, plotted on logarithmic coordinates, are shown in *Fig.* 3. The authors compare these specimens on the basis of stress at the fatigue endurance limit; that is, the stress at the "knee" where the curve becomes horizontal. However, as stated above, our interest is in the finite life region of the diagram; that is, in the characteristic of the curve lying to the left of the "knee". Observe that as the severity of the specimen section is increased the slope of the curve increases, and that the curves, if extended leftward, tend to cross one another. . . .

[2] *Fatigue of Metals*, Moore and Kommers, p. 199.

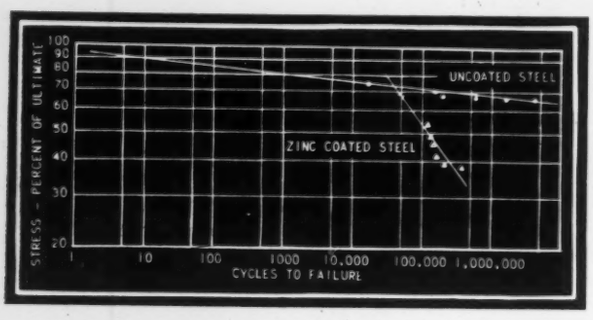


Fig. 7—Plated coatings affect fatigue strength in a manner similar to rolling

Specimen versus Part

Permissible stress at the fatigue limit of a machine part may be less than ten per cent of the ultimate strength of a material, whereas laboratory test specimens may indicate fifty per cent or more as obtainable. The differences in slope of fatigue curves suggests that this characteristic promises a way whereby we may eventually greatly improve our accuracy in determining the strength of machine parts. This is now being done in rating the load capacity of ball bearings, roller bearings and certain gears. . . .

If a sufficient number of specimens were tested, and if the stress scale proportionality were the same for all specimens, it is probable that the sloped lines in *Fig.* 3 would all tend to converge toward a point in the vicinity of 1000 cycles and 90,000 pounds per square inch, somewhat as indicated in *Fig.* 4 in which the fatigue slopes of specimens 1 and 4 of *Fig.* 2 are shown as converging bands rather than lines. This point of intersection is suggested because the ultimate strength of the material tested by Moore and Kommers is approximately 95,000 pounds per square inch. The point of intersection would probably be at a considerable number of stress cycles because the ductility of the material permits adjustment of stress through yield, thus reducing the influence of local highly stressed points. For brittle material, the intersection point of the fatigue curves for the type of specimens shown in *Fig.* 2 would probably be near the ultimate strength and nearer one cycle of stress. . . .

Fig. 4 shows an *S-N* diagram replotted from data contained in an A.S.T.M. research report[3]. By combining all the data for heat treated SAE 4340 steel in a single *S-N* diagram, we have a total of 59 failed points which roughly outline a scatter band of the general form suggested in *Fig.* 6. . . .

Surface treatment of the test specimens other than the degree of smoothness has a marked effect on fatigue strength. Horger and Maulbetsch[6] compared normal, well-finished specimens with specimens that had been subjected to a rolling operation which introduced compressive stresses in the surface layer with the results shown in *Fig.* 6. Since the rolled specimens were pre-stressed in compression the subsequent tension stresses during the test were reduced, hence the difference in the slope of the curves for the two types of specimens. Since this treatment should be ineffective in a tensile test the lines should converge.

Coating Reduces Life

Swanger and France[7] made tests on zinc-coated specimens by which they demonstrated loss in strength due to the zinc coat. *Fig.* 7 shows the increase in slope of the curve for the coated specimens and the convergence toward the left.

From the foregoing it seems reasonable, as a working hypothesis, to assume that, except possibly for very ductile metals, the slope of the fatigue curve may be considered a measure of true stress and that the fatigue curves for varying stress concentrations converge toward a point near the tensile strength of the material and at some considerable number of stress cycles. . . .

Only occasionally are fatigue tests on machine parts run at various loads. In the very few cases where data from a reasonable number of such tests run at sufficiently large load range are available on commercially identical parts, a reasonable number being one or two hundred, we find that the scatter of the test points when plotted on logarithmic co-ordinates falls within a well-defined pattern which tends to radiate from a point at high stress and a low number of stress cycles and to diverge to a broad band at low stress and high number of stress cycles just as was suggested in *Fig.* 5. This is clearly shown in *Fig.* 8 which is a fatigue diagram of about 200 complete automobile and truck rear axles of various makes and sizes. The stress scale shown in this diagram is not true stress but is believed to be proportional to true stress. . . .

The slope of the average durability line is approximately seven, while the slopes of the upper and lower limits of the scatter band are, respectively, nine and five. The intersection point at the left of the diagram should lie near the ultimate strength of the material (approximately 300,000 pounds per square inch) which, if proved, would supply us with a true measure of stress. . . .

[3] Report of the Research Committee on Fatigue of Metals, A.S.T.M. Meeting, June 1941.
[4] Oberg and Johnson, A.S.T.M., Vol. 37, page 199.
[6] O. J. Horger and J. L. Maulbetsch, A.S.M.E., Vol. 58, page A92.
[7] W. H. Swanger and R. O. France, A.S.T.M., Vol. 32, page 439.
[9] A. W. Macauley—*The Automobile Engineer*—July 1923.
[10] Haakon Styri—*Mechanical Engineering*—June 1925.

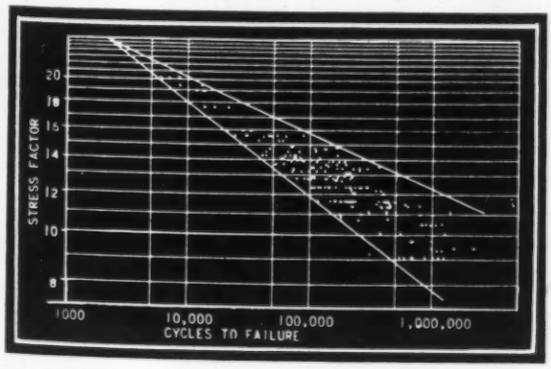


Fig. 8—Two hundred tests on spiral-bevel, rear-axle gears provide a complete picture of the stress-frequency relationship

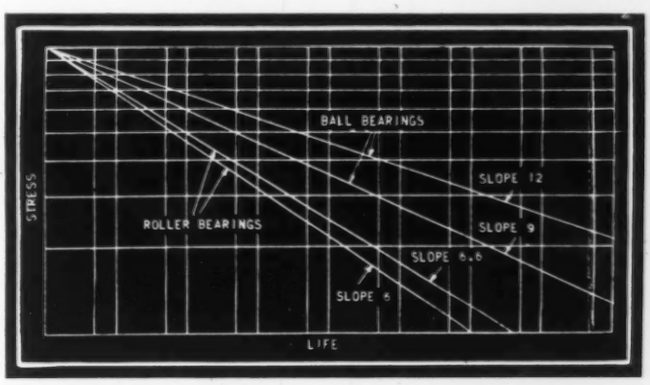


Fig. 9—Data obtained from catalog ratings of anti-friction bearings shows the same characteristic convergence at the point of minimum frequency

Other data approaching these requirements have been accumulated by the various ball and roller bearing manufacturers but little has been published. However, fatigue data on ball and roller bearings need not in all particulars agree with fatigue data on other forms of machine parts since failure of rolling bearings originates below the surface of the material. Surface influences, which play so important a part in fatigue of ordinary machine parts are, therefore, absent in rolling bearings which would be expected to influence the permissible stress and possibly the form of the scatter band. The scatter band as reported by Macauley[9] and by Styri[10] is parallel to the average life curve throughout the life range shown. . . .

It has been shown by Hertz and others that the stress in ball bearings varies as the cube root of the applied load and that in roller bearings the

stress varies as the square root of the applied load. When the diagram is plotted in the usual terms, stress versus life, as in *Fig.* 9, it is found that the slopes for ball bearings are 9 and 12, while for roller bearings the slopes are 6 and 6.66. The steeper slope for roller bearings presumably is the result of increased stress at the end of the roller due to the discontinuity of shape which thus constitutes a region of stress concentration. This further confirms the hypothesis that slope is a measure of stress. . . .

Service Cannot Be Simulated

The common belief that reliable tests can be conducted in the laboratory by reproducing the conditions of service is wholly erroneous. By the time the laboratory investigator has provided for all of the conditions that occur in service, he will, in the case of automobile parts, find himself on the road with a complete automobile and even then he will not represent the type of driver who most severely taxes the strength of the machine.

Many laboratory tests have been and are still being used by which to grade materials and processes that are now known to have been costly to the automobile and other industries. Thus, the fiction that a carburized part should have a hard case to resist wear and a tough core to resist breakage arose from laboratory impact tests. In this test the strength of the part was judged by the number of hammer blows a part would withstand before fracture and since, for example, gear teeth resisted impact fracture in accordance with the physical properties of the core, it seemed logical to specify heat treatments to bring out the best compromise between the imagined requirements of the case and the core. Being compromises, these heat treatments were not the best for either region.

One Blow Ruins Tooth

If, instead of counting the number of hammer blows to produce fracture, the gear tooth had been examined after the first impact the tooth would have been found bent and, therefore, ruined. Hence it would make no difference how many more blows were required to fracture the tooth. This compromise heat treatment resulted in reducing the quality of many millions of gears before it was realized that gear teeth fail by fatigue and that fatigue failure, for the usual depth of carburization, always originates at the surface of the case. It then became clear that the heat treatment should consider the requirements of the carburized case only and that the properties of the core were relatively unimportant since the core serves mainly as a stuffing for the case. . . .

Efforts to improve parts by improving surface finish may sometimes have the opposite effect. Highly finished fillets may lead to a false sense of security if they are applied to parts having high internal stresses resulting from manufacturing operations, or, as in ground gear teeth, the grinding operations may introduce high surface stresses in tension and thus promote fatigue failures. It is the writer's opinion that from the standpoint of strength more harm than good results from the grinding of gears. The surface stresses from grinding are often so great as to produce visible or magniflux surface cracks but, whether detectable or not, surface tension is frequently serious. Since fatigue cracks start on the side of the gear tooth that is loaded in tension, the effective stress is the grinding pre-stress plus the working stress. . . .

Clear evidence of fatigue failure does not prove that the failed part was primarily responsible. A bolt may fatigue because it was not properly tightened during assembly, a gear may fatigue due to improper support or to a failed bearing, a crankshaft may fatigue due to inadequate or maladjusted vibration damper and so on without end. It sometimes happens, therefore, that immediate corrections are made to the wrong part and the true trouble belatedly discovered. . . .

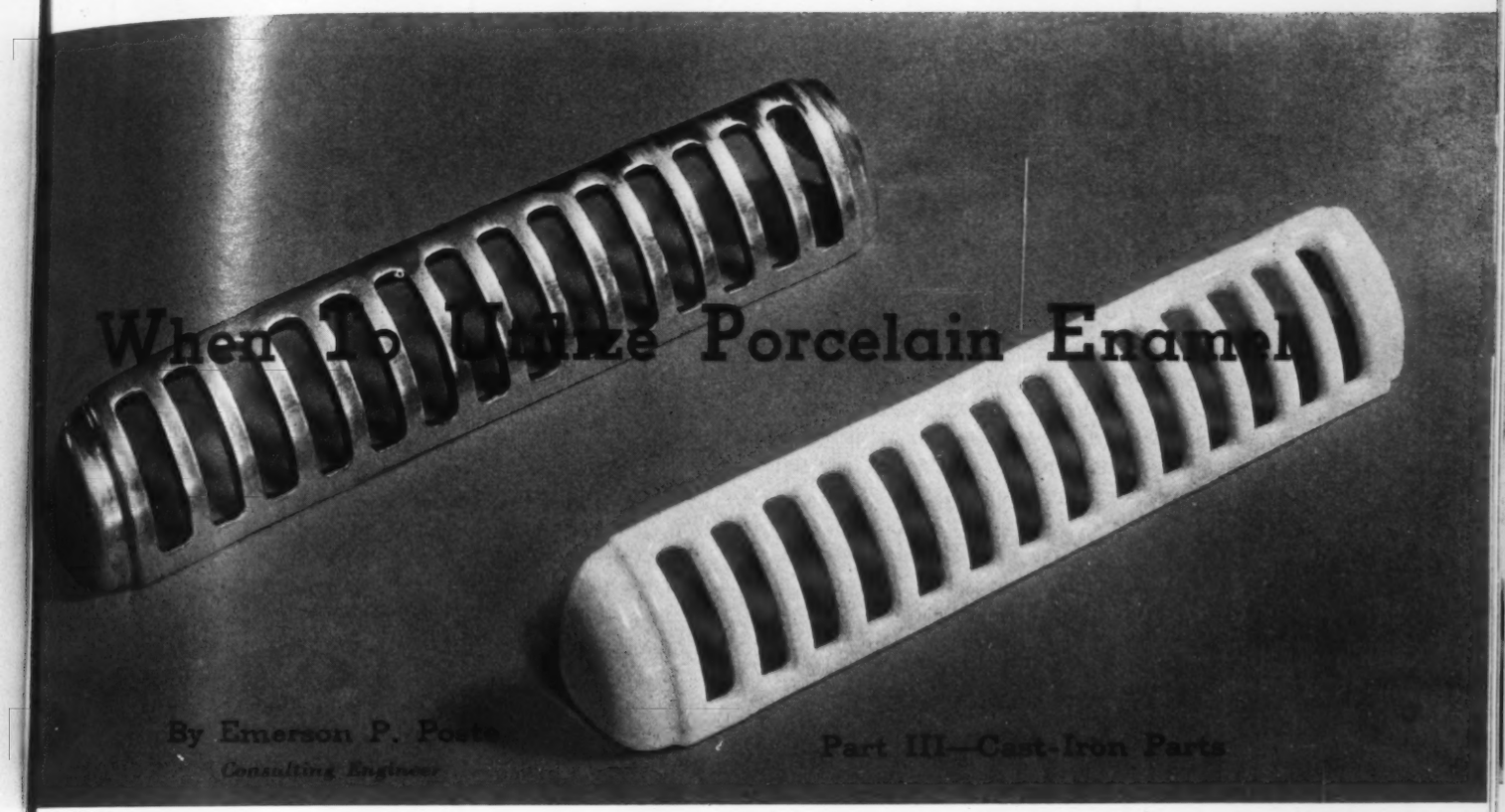
Lifetime of Thirty Miles

Rear axle automobile gears are at worst stressed at low gear torque one cycle out of every one thousand cycles. The lifetime requirements of such gears, therefore, is 100,000 cycles at low gear torque equal to approximately thirty miles of travel. Due to the scatter of test points this is 250,000 cycles on the average curve.

Fatigue data from machine parts can profitably be studied for the purpose of constructing empirical formulas by which load capacity may eventually be accurately calculated. Let it be assumed that fatigue data have been accumulated on one hundred coil springs of three quite different sizes. If the stress is calculated and the points plotted on a logarithmic chart, it will be found that all springs of one size lie within a definite scatter band having the same mean slope as the other two. . . .

From this plot it may be immediately concluded that the formula used for calculating stress is in error since by its use it was impossible to predict relative load capacity. If there is now introduced into the formula a suitable size factor such as to bring the three curves into coincidence, improved accuracy will result.

By this procedure accurate load capacity formulas may be constructed for any machine part no matter how complex the stress pattern may be. The stress calculated by such formulas will not be true stress but this is unimportant because reliable means by which to determine load capacity are now available.



When To Utilize Porcelain Enamel

Part III—Cast-Iron Parts

By Emerson P. Poste
Consulting Engineer

RELATIONS between porcelain enamel and cast iron have never been as clearly defined as have those between enamel and sheet metal. This is incidental to the facts that cast iron is more complex structurally than is low carbon steel or ingot iron and that cast iron for enameling is made under conditions not as favorable to research and control as those prevailing with the large steel companies.

The major problem involves a condition in iron which causes a blistering of the enamel, particularly when applied by the wet process as compared with the dry. The enameled metals section of the Bureau of Standards and the enamel division of the American Ceramic Society, as well as various private interests, have conducted extensive research on the problem. In general, it was concluded that a particular form of carbon incidental to the graphitization of cementite was responsible for blistering, particularly that involved in a thin surface layer termed "microchill." The blisters were attributed to the evolution of oxides of carbon during a critical period in the fusion of the enamel.

More recently certain investigators have concluded that hydrogen is the cause of the blistering and that there is a relation between hydrogen evolution and the state of carbon, which had escaped attention in the former research.*

Experience has taught the industry that best re-

* *Journal*, American Ceramic Society, 24, 249, 1941.

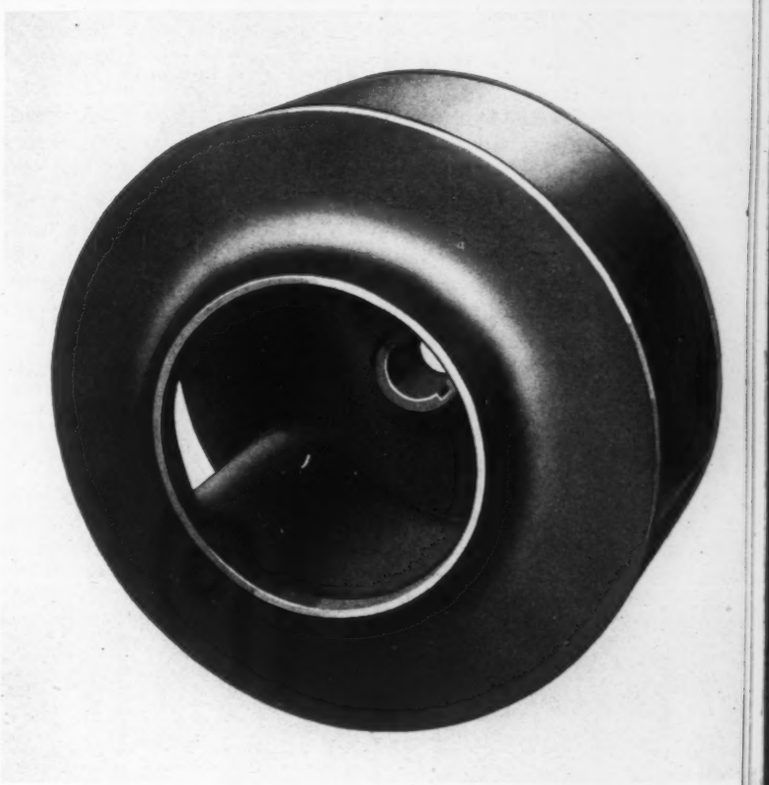


Fig. 1—Top—Uniform sections and rounded corners facilitate enameling as well as providing attractive parts. Changeover from chromium-plated grille at left with larger radii on slots, improves general appearance

Fig. 2—Above—Smooth, glossy surface on cast pump impeller increases the efficiency of the pump as well as making it resistant to corrosives and abrasives

sults come from the use of cast iron of rather definite chemical composition. One authentic reference† gives the following as an average analysis of cast iron suitable for enameling purposes:

Element	Per Cent
Silicon	2.50
Manganese	.70
Phosphorus	.75
Sulphur	.075
Total Carbon	3.30-3.40
Combined Carbon	.50- .60
Graphite	2.80-2.90

The silicon content obviously should be decreased or increased for thicker or thinner sections.

Some foundrymen have found an arbitrary formula for "carbon equivalent" helpful in the development of iron for enameling. It is

$$\frac{\%\ \text{silicon} + \%\ \text{phosphorus}}{3} + \text{total carbon} = 4.3\%$$

This leads to an iron close to eutectic composition.

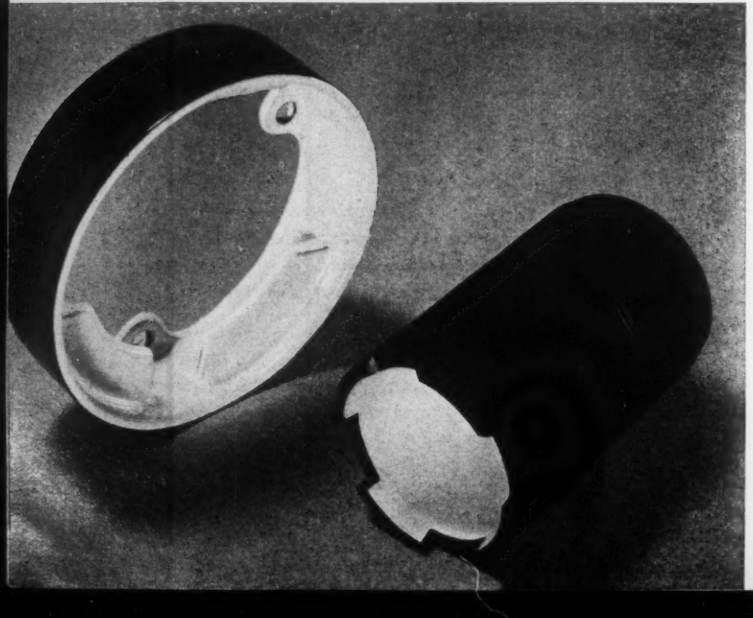
Foundry practice as a whole should be such as to afford a reasonably uniform, dense structure, free from segregation, porosity, and slag enclosures, and the surface should be such as to sandblast easily to a fairly smooth surface free from appreciable defects. To accomplish these results certain fundamentals of design and foundry practice are required.

Uniform Castings Are Important

DESIGN OF CAST-IRON PARTS: The basic principles involved in the correct design are fundamentally the same as those developed in the previous installments of this series. The fact must be realized that designs which might be desirable from a mechanical point of view may involve enameling difficulties. Probably the most important consideration is to approach as nearly as possible a uniform thickness of metal throughout a given piece. For example, a casting that might logically be reinforced by a rib if enameling were not involved should be flanged instead, thus avoiding the hairlining that otherwise might result.

† *A Manual of Porcelain Enameling*—Manson, page 49.

Fig. 3—Green exterior and white interior porcelain-enameled ring and white-enameled pump cylinder liner. Parts are dipped and are brushed on machined surfaces. On pump liner, this thins coat at corners of notches, lessening danger of chipping



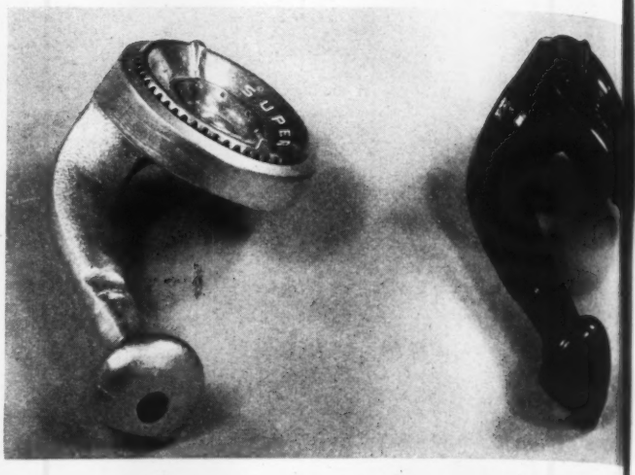


Fig. 4—Gleaming, easy-to-clean black enamel replaced aluminum finish on cast gas burners

Before going further into the details of design, a brief statement as to the chief difficulties in enameling cast iron is in order. Blistering, the most frequent trouble met in the enameling of cast iron, has been defined as "the occurrence of bubbles which remain at the surface of the enamel". The condition may be related to the composition of the iron, as previously mentioned, or may come from errors in design or processing.

The second type of defect, termed "hairlining", has been described as "lines appearing in the enameled surface in the shape of a groove and not extending to the base metal. In white enamels the lines appear darker than the surrounding surface." This difficulty may result from faulty design of casting or improper processing.

Should Control Warping

Warping is a "change in the original contour of the piece produced by one of the enameling operations". It may be due to wrong composition of cast iron, poor design, or incorrect processing.

Metallurgists have done much in the development of iron compositions and details of foundry practice that will keep these troubles at a minimum. Also, enamel technologists have been constant in their efforts to produce enamels that will be resistant to blistering and hairlining and that can be turned to a satisfactory finish at temperatures low enough to avoid warpage. With the results of this progress available, the designer plays an important part in the success of the enameling of cast iron.

In most cases the production of a casting satisfactory for enameling involves a pattern of the same shape as the finished casting. An exception occurs in connection with certain parts that deform in a systematic manner due to the heat of

the enameling furnace. In such cases the pattern must so deviate from the desired final shape as to compensate for this tendency to warp and produce an enameled casting of the desired shape.

To avoid blistering a casting should be free from sections uneven in thickness, such as heavy lugs and ribs. Careful use of flanges and attachment tabs will eliminate the objectionable features that would be entirely satisfactory in castings not to be enameled. The chief objective should be to provide sections which absorb heat evenly.

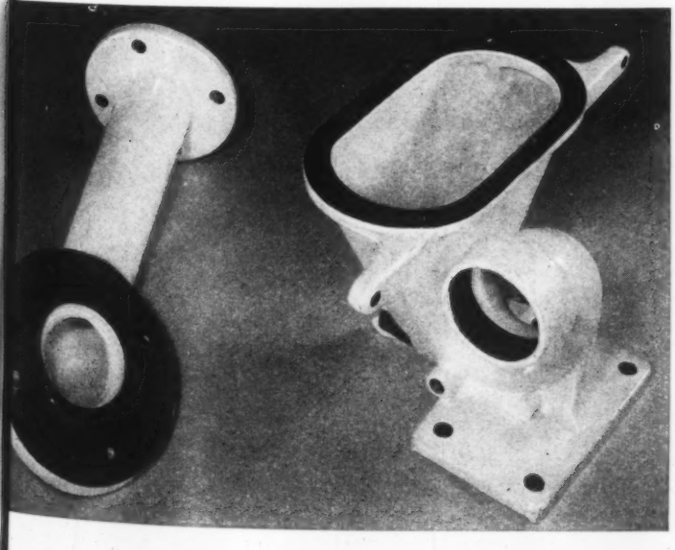
Warpage due to faulty design is usually the result of uneven strains set up in the casting during cooling after casting, while being sandblasted or during firing. In such cases thin ribs at the proper places may reduce warpage and still permit satisfactory enameling. It is not always possible to foresee all of the requirements in a given case. Castings from new patterns should be observed carefully throughout the enameling process and such changes made in the pattern as preliminary experience may indicate.

Heavy Ribs Cause Hairlining

Hairlining may be caused by ribs being too deep and too heavy, causing uneven heat absorption with consequent different rates of expansion during a normal firing cycle between thin section and area over ribs. While a slower heating cycle would tend to reduce the hairlining such a handicap should not be placed on the enameling operation. Reduction of the depth and thickness of the ribs to a minimum affords a far more satisfactory solution to the problem.

* For further information the reader is referred to *Production of Castings for Porcelain Enameling*, Porcelain Enamel Institute, July, 1937.

Fig. 5—Sterilizer parts enameled for sanitary purposes Wet process enameling employs two dipped coats and one additional coat, sprayed on the exterior. Machined surfaces are brushed to remove surplus enamel before firing



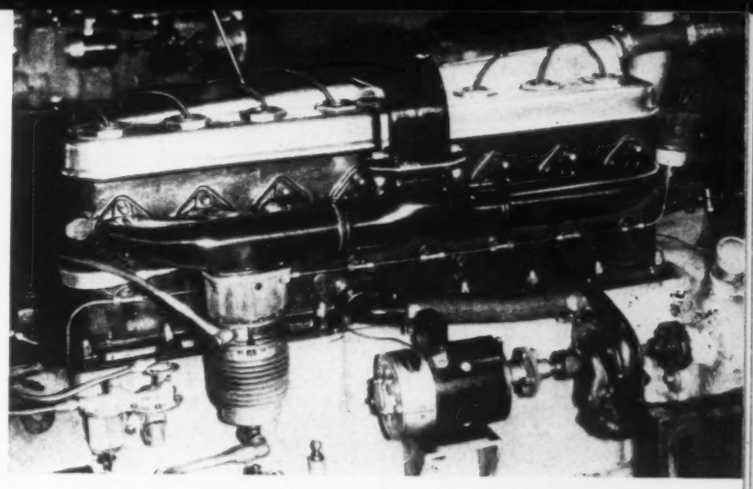


Fig. 6—Black enameled interior and exterior of exhaust manifold reduces friction on the flow of gases and provides neat, easily-cleaned, rust-free surfaces

Sharp outside and inside corners should be avoided carefully, see *Fig.* 1. The former renders complete coverage difficult and promotes chippage if the required enamel thickness is realized. Sharp inside corners cause the enamel to pile up, with consequent blistering and sometimes crazing, or may promote fine fractures in the finished enamel. Chipping may also occur. All corners and fillets should be rounded to radii of at least ⅛-inch.

FOUNDRY PRACTICE: While the designer may not be responsible for foundry practice he should be sufficiently conversant with the basic requirements so that he may know whether a given case of trouble is due to faulty design or improper molding, melting or pouring methods.*

Proper gating is essential. The mold should be gated so that the iron will distribute itself uniformly; in general, gates should be located on the edges of thin castings; a casting which is to be enameled should not be gated on its face, or its back. If a casting is heavier in one portion than in another, it should be so gated that iron will feed from the thin to the thick sections. Gating should also provide for the removal of all possible slag from the molten iron before it enters the mold.

Graphitic Facings Should Be Avoided

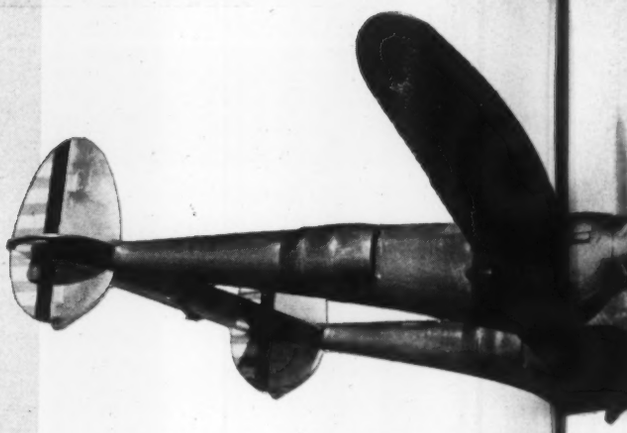
Condition of the molding sand is important. The water content should be the minimum which will develop satisfactory mold strength. Maximum permeability of the mold is thus assured. Graphitic facings should not be used, but certain ground coke facings are satisfactory. For any facing caution should be observed to insure uniform distribution over the surfaces to be covered.

Conditions in the cupola should be such as to avoid burned iron or improper removal of slag. Details such as coke bed, air velocity and volume, melting ratio, and temperature of molten iron have a marked effect on the quality of enameling possible. The casting, as soon as it is sufficiently cooled, should be shaken free from sand and removed from the sand pile. Castings which are allowed to remain buried or partially buried in the sand overnight will cause blister.

(*Continued on Page* 144)

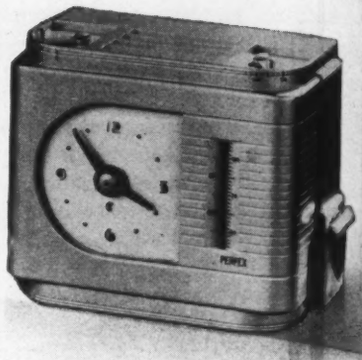
Design Features IN NEW MACHINES

(For new machine listing see page 158)



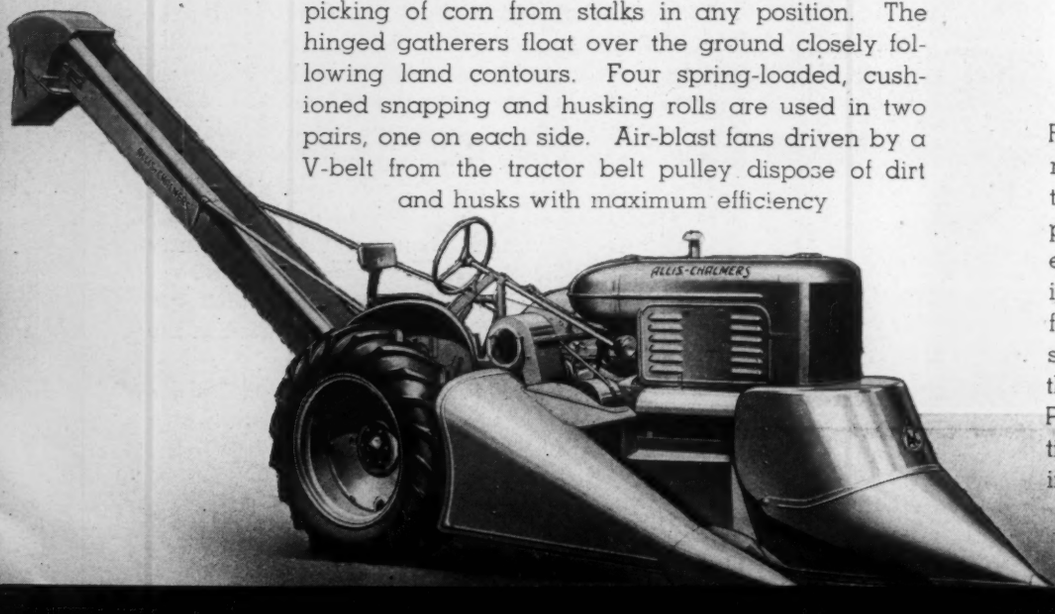
Above—Twin-engined, double-fuselag Lightni the fastest airplane in the world. Bu le acco dates the pilot-gunner in this twin-e place p Two 12-cylinder, 1150 horsepower, liq lison en each mounted in one of the twin fu e two bladed, controllable pitch propellers opposite tions. Gross weight is approximately 1 s, wing 52 feet and length 3

Left—Completely balanced lightweight reciprocating members make possible short-stroke speeds up to 2000 per minute in Fellows gear shaper. Cutter spindle is held in a relieving-type saddle the maximum movement of which does not exceed .005-inch. Using a pinion-type cutter the machine is adaptable to the cutting of both internal and external helical and spur gears. Guide mechanism consists of two bronze shoes operating in involute-sided grooves.



Left— s self-st clock a set of oper operat contr Perfex most at elem of the with he plied metal th elem t condu Qui and eli tion ration i obt le lead elim twin-c swi es conto sea ecting acr ary ter

Below—Accessibility is an important factor in Allis Chalmers' corn harvester. Servicing and adjustment can be accomplished without the removal of parts. Balanced construction is provided by suspending the harvester from beneath the rear axle of the tractor. Design of gathering mechanism permits the picking of corn from stalks in any position. The hinged gatherers float over the ground closely following land contours. Four spring-loaded, cushioned snapping and husking rolls are used in two pairs, one on each side. Air-blast fans driven by a V-belt from the tractor belt pulley dispose of dirt and husks with maximum efficiency



Right—Head of Cross universal milling machine may be adjusted to any angular position in any plane by means of pin mountings equipped with anti-friction bearings. V-belt drive is powered from a selective gear box using self-contained motor driving through a wormgear reduction. Pyramidal column provides exceptional rigidity, uniform section, uninterrupted contour and total absence of openings

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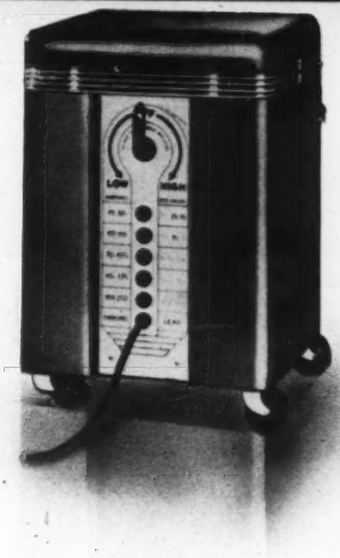
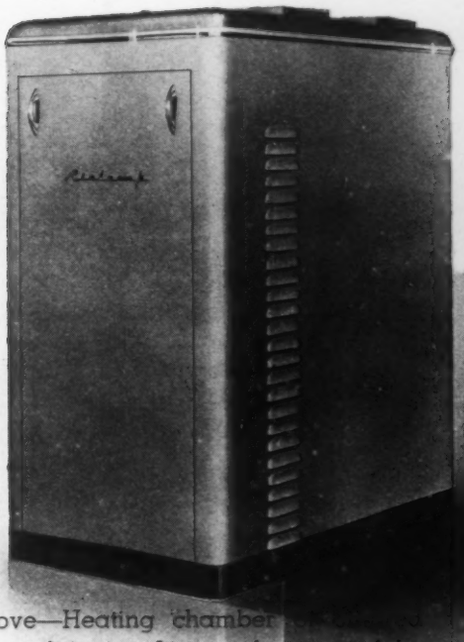


Left—Capable of a welding current output variable in 30 steps from 15 to 250 amperes the Allen arc welder is efficient and extremely flexible. Ruggedness and reserve capacity of the transformer is exemplified by the fact that after continuous operation for 8 hours with the transformer short-circuited its efficiency is unimpaired. Portability of the unit is enhanced by swivel casters



Above—Heating chamber [illegible] air conditioning Airtemp furnace is fabricated from copper-bearing steel for corrosion resistance. The heating chamber is designed so that the speed of air travel varies directly as the temperature of the radiating surface. Rubber vibration-absorbent mounting on the fan and motor assembly prevents transmission of vibration. Attractive cabinet is bonderized to resist rust

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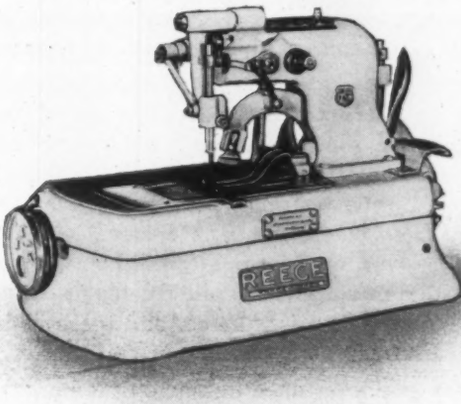
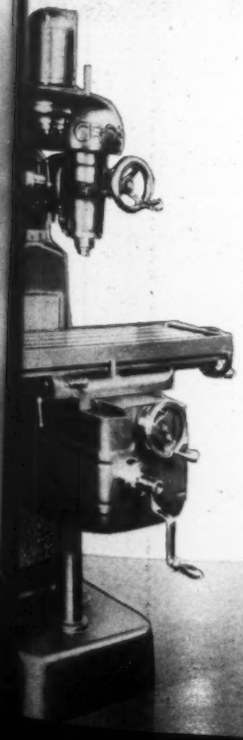
Below—Weight of reciprocating and oscillating parts in Reece buttonhole machine is an important design factor because of high-speed, sudden starts and stops. Aluminum alloy forgings and castings previously used have been replaced, because of material shortages, by equally satisfactory thin steel stampings. Actual weight reduction is effected in many cases. By use of two thread loopers instead of one the speed of most operating parts is held to 2000 revolutions per minute; stitching speed is comparable to that of a machine operating at 4000 revolutions per minute





Right—Reversible electric motor driving through step pulleys imparts a hydraulically controlled movement to the work spindle on Ex-Cell-O internal thread grinder. Hydraulic operation is also employed to provide quick and smooth operation of the wheel slide. Adjustable table dogs are provided so that the wheel may grind in both directions, if desired. In this case a special backlash compensator is used to insure that the wheel traverses the same path when traveling in either direction on a working stroke

MACHINE DESIGN

Editorial

Large Plants Having Their Day—What of the Smaller?

MOST manufacturers of machinery have recognized the inevitable pressure on them to take a wholehearted part in the defense program. Particularly so is this the case with the larger companies. Through government orders, subcontracting agencies and individual initiative, these concerns have set up work programs that without doubt will keep them fully occupied for the duration of hostilities.

Farsightedness on the part of these companies has enabled them to secure the "pick" of the defense orders. They have placed themselves in a position to influence the selection of their plants for specific types of work most suited to their standard line of production and to their manufacturing facilities. Conversely, they have obtained work that will best enable them to adjust their production back to normal when the time comes. In some cases they have collaborated with the government in the building of entirely new additions to their plants, thus not only serving an immediate purpose but giving them the opportunity later of producing new lines of equipment upon which they otherwise might not have been likely to venture.

Unfortunately these conditions do not apply to the multitude of smaller manufacturers. Investigation shows that some machinery companies not engaged in defense work have had to curtail production, and that others have a constant fear that because of priorities and restrictions in supply they will be compelled to follow suit or possibly close down. It is inconceivable, however, that even the smallest company possessing any form of machine shop equipment would permit itself to reach a state of slackness while the biggest program of production of war equipment ever undertaken is in effect and there is drastic need for every single machine-hour and man-hour the nation can muster.

The same applies to other companies not engaged in machinery manufacture but in production of goods allied with or applicable to machinery. Many of these have been sufficiently alert to adjust their outlook and facilities to the production and sale of equipment, parts or materials to meet current essential needs, rather than to attempt to continue the manufacture of unessential items that sooner or later inevitably must be curtailed.

With all of the production clinics being held in various centers, with the opportunity to review potential subcontract work in the government exhibit trains traveling around the country, and with the establishment of innumerable contract distribution offices in the larger towns, machinery companies—large or small—should have little difficulty in finding the type of work most nearly approaching that which they can effectively handle, and for the production of which supplies or substitutes unquestionably will be made available.

L. E. Jerry

Approximating Gear Ratios by Continued Fractions

By R. C. Binder

Associate Prof. of Mechanical Engineering
Purdue University

OFTEN in the solution of gear train problems it becomes necessary for the designer to approximate a gear ratio which will enable him to use practical gears and to attain the accuracy and precision which is dictated by the requirements of the application. A convenient method of determining this numerical value or ratio is that which involves the use of "chain" or "continued" fractions.

Such a continued fraction is one whose denominator contains a fraction which, again, in its denominator, contains a fraction and so on. When the numerators of these fractions are each unity the resulting expression converges rapidly as is demonstrated by the following example.

Assume a gear train is to have a ratio of 491/1107. The first step is to express this ratio in terms of a continued fraction

$$\frac{491}{1107} = \frac{1}{\frac{1107}{491}} = \frac{1}{2+\frac{125}{491}}$$

The ratio, 125/491, is then treated in a similar manner

$$\frac{491}{1107} = \frac{1}{2+\frac{125}{491}} = \frac{1}{2+\frac{1}{\frac{491}{125}}} = \frac{1}{2+\frac{1}{3+\frac{116}{125}}}$$

Continuing the process to any desired degree of accuracy results in

$$\frac{491}{1107} = \cfrac{1}{2+\cfrac{1}{3+\cfrac{1}{1+\cfrac{1}{12+\cfrac{1}{1+\frac{1}{8}}}}}}$$

The common fraction is converted into a continued fraction by dividing the numerator into the denominator; the residue is divided into the divisor, etc. Successive quotients then are the successive denominators of the continued fraction. A numerical check can be made by reversing the steps.

Expression of the numerical value by a continued fraction gives a series of successive approximations alternately above and below the true value and approaching it rapidly. This is demonstrated by the following table based on the foregoing example.

The third approximation, 4/9, is simple and convenient if an accuracy of .2 per cent is satisfactory. Computation should be made for each step to determine the degree of accuracy.

As a second example, it may be desired to obtain a speed ratio given by the

No. of Steps	Magnitude of Approximation	Numerical Difference	Per Cent Difference
1	$\frac{1}{2} = .500$	+.056459	+12.7
2	$\frac{1}{2+\frac{1}{3}} = \frac{3}{7} = .428571$	−.01497	− 3.4
3	$\frac{1}{2+\frac{1}{3+\frac{1}{1}}} = \frac{4}{9} = .444444$	+.000903	+ .20
4	$\frac{1}{2+\frac{1}{3+\frac{1}{1+\frac{1}{12}}}} = \frac{51}{115} = .443478$	−.000063	− .014
5	$\frac{1}{2+\frac{1}{3+\frac{1}{1+\frac{1}{12+\frac{1}{1}}}}} = \frac{55}{124} = .443548$	+.000007	+ .0016
6	$\frac{1}{2+\frac{1}{3+\frac{1}{1+\frac{1}{12+\frac{1}{1+\frac{1}{8}}}}}} = \frac{491}{1107} = .443541$	.000000	.000

decimal, .14159265 (which is the familiar $\pi - 3$). This decimal can be expressed as

$$\frac{14,159.265}{100,000,000}$$

which fraction can be transformed into a continued fraction to give

$$.14159265 = \frac{1}{7+\frac{1}{15+\frac{1}{1+\frac{1}{288+\frac{1}{1+\frac{1}{2+1}}}}}}$$

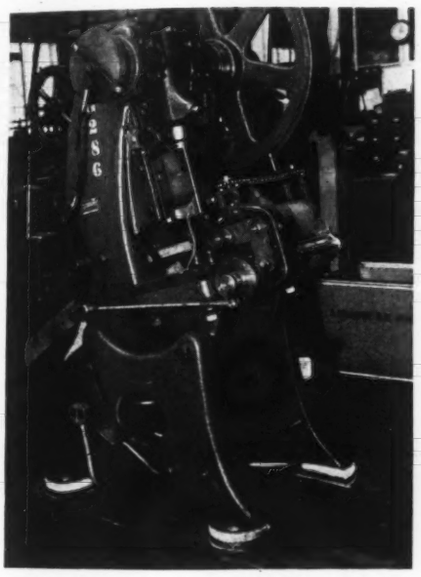
First three approximations of this continued fraction are

No. of Steps	Magnitude of Approximation	Numerical Difference	Per Cent Difference
1	$\frac{1}{7} = .1428571$	+.00126	+.89
2	$\frac{1}{7+\frac{1}{15}} = \frac{15}{106} = .1415094$	−.0000832	−.059
3	$\frac{1}{7+\frac{1}{15+\frac{1}{1}}} = \frac{16}{113} = .1415929$	+.0000003	+.0002

It is apparent, in this case, that even the first approximation agrees with the desired ratio to within less than one per cent. By the third approximation the difference in agreement is insignificant although the ratio 16/113 may be less convenient than one of the previous two.

Applications

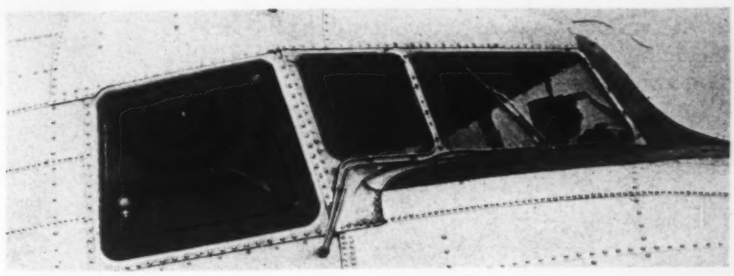
of Engineering Parts and Materials



Isolates and Absorbs Vibration

DESIGN of the legs or pads of such machines as the shearing press illustrated should be advanced, taking cognizance of the type of vibration insulation which is to be used as the machine support. If, as in this case, felt is to be used, the area under the pad should be a function of the weight of the machine. Capable of supporting loads of from 0 to over 35 pounds per square inch, the American Felt company's material used in this application will isolate frequencies as low as 18 cycles per second and in excess of 40 cycles per second.

In installing felt vibration absorbers, particularly under large flat surfaces, small pieces are preferable to the indiscriminate use of large sheets. Care should be exercised to avoid the transmission of vibration through bolts or other devices for anchoring the machine to its foundation.



No Magnetic Interference

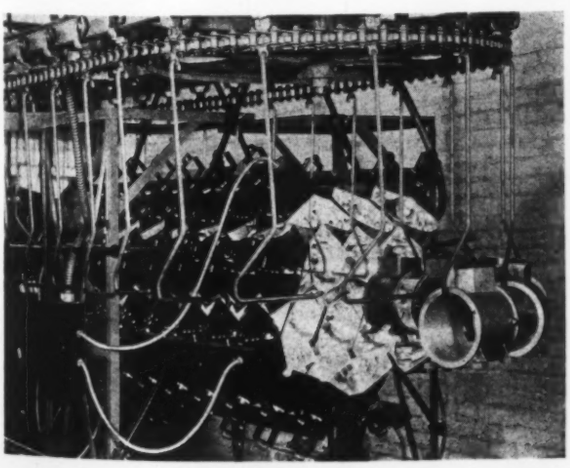
PROXIMITY of the windshield wiper to the magnetic compass on the instrument panel of commercial airplanes necessitates that the moving parts of the wiper be made of nonmagnetic material. The several specifications of light weight, rigidity and high strength have resulted in the selection of aluminum bronze for this service.

Because of the severity of operating conditions and the comparatively high hydraulic pressure used in the drive, sufficient safety factor is required in the material for the valve and valve seat mechanism to prevent pounding. Aluminum bronze complies with these requirements as is amply demonstrated by the fact that after over two million reciprocating cycles of the motor and associated parts the amount of wear is negligible.

Lamps Effect Shrink-Fit

IN SPECIFYING a press fit between steel and aluminum parts care should be exercised to insure that the overlap of dimension is not excessive—otherwise scoring and galling will result. On the other hand, decreasing the amount by which the inner piece is oversize may introduce the hazard of loose-fitting parts. In this application at the Westinghouse small motor plant aluminum motor frames are heated by infra-red light to 150 degrees Cent. This increases the 6¾-inch diameter bore by .02-inch which is sufficient to allow the wound primary coil to be dropped readily in place.

Traveling at the rate of 30 feet per minute a rotary conveyor carries the aluminum motor frames through a tunnel formed by a battery of fifty-six 375-watt lamps. By the foregoing method a proper fit is obtained between the hard and soft metal parts obtainable in no other way without serious risk of an excessive number of rejects.



ASSETS *to a* BOOKCASE

Practical Solution of Torsional Vibration Problems

By W. Ker Wilson; volume II, second edition, published by John Wiley & Sons, Inc., New York; 694 *pages,* 5½ *by* 8½ *inches, cloth bound, available through* MACHINE DESIGN *for* $8.50 *postpaid.*

Supplementing the first volume of this work which was reviewed in the March, 1941, issue of MACHINE DESIGN this second volume completes the thorough and authoritative treatment of the subject of torsional vibration in machines. Steady increase in speeds, loads and power of machines and prime movers compels more and more careful attention to the subject of torsional vibration and its isolation and reduction.

Determination of stresses resulting from vibration at resonant speed as well as the measurement of frequency and amplitude phenomena is complemented by a thorough analytical presentation of the various torsional vibration damping devices, including several types of rotating pendulum vibration absorbers.

Technique of tuning operating systems is exhaustively investigated to the end that severe critical zones may be eliminated in the normal operating speed ranges of machinery. Factors are presented which affect the selection of stiff or flexible connecting shafts for the location of such critical zones either above or below the normal operating range.

Contained in the text are a large number of problems completely worked out exemplifying the basic principles involved in the preceding material. This facilitates calculations without requiring recourse to a considerable amount of research through the remainder of the book before the calculation can even be started.

□ □ □

Elementary Fluid Mechanics

By John K. Vennard; published by John Wiley & Sons, Inc., New York; 351 *pages,* 6 *by* 9 *inches, cloth bound; available through* MACHINE DESIGN *for* $3.50 *postpaid.*

Prepared primarily for the beginner or young engineer in the field of hydraulics, rigorous mathematical exposition is sacrificed in favor of a rational, understandable presentation. Thus, with few exceptions purely empirical relationships covering hydraulic phenomena are subordinated to the rational and the analytical development.

Beginning with a discussion of the physical properties of fluids and fluid statics the book progresses logically through frictionless flow of an ideal fluid and a thorough working demonstration of Bernoulli's theorem. Laminar and turbulent flow of fluid through pipes and open channels introduces a discussion of a similar flow through weirs of various shapes and sizes for metering purposes.

The book concludes with an excellent elementary presentation of fundamental aerodynamic relationships. Profile and frictional drag are here covered as well as the effect of high velocities upon drag. Also the momentum and circulation theories of lift are given in an understandable manner as is some discussion of the effect on lift of foils of finite length. The interrelationships existing between hydraulics and aerodynamics are thus effectively developed by pointing out the analogous phenomena of an incompressible fluid on the one hand and a compressible on the other.

□ □ □

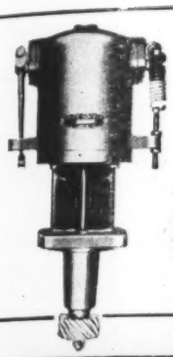
Mechanical Engineers' Handbook

By Lionel S. Marks; fourth edition, published by McGraw-Hill Book Company, New York; 2274 *pages,* 5 *by* 7 *inches, flexibly bound in imitation leather; available through* MACHINE DESIGN *for* $7.00 *postpaid.*

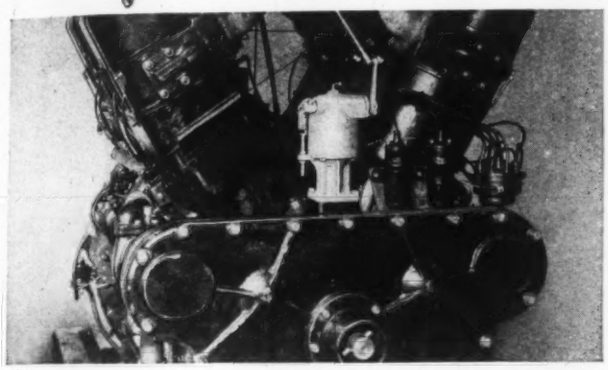
Standardization of machine elements and the advances in practice, theory and in the systematization of existing knowledge which have occurred during the 11-year interval since the last edition of this handbook have occasioned extensive changes, modifications and rearrangements in the current edition. In consequence the list of contributors is practically doubled, now numbering over 90.

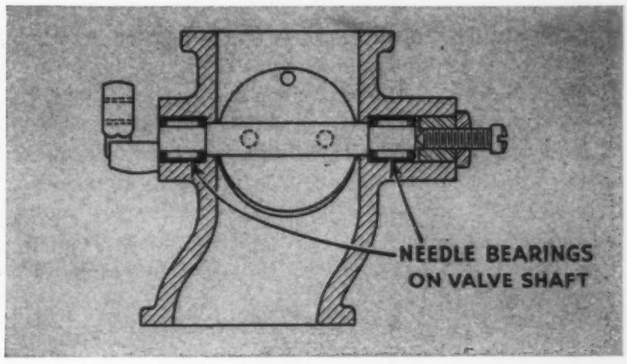
Among the new subjects are the theory of models, classic behavior of materials, stress concentration, creep, packing, wind pressure on structures, sound and noise, automatic control of processes and powder metallurgy. In order that, with the addition of these new subjects, the book be not materially increased in size a rigorous exclusion or condensation of material which has become or is in the process of becoming obsolete has been conducted. For example, the A.S.M.E. power test code, a condensation of which has been included in previous editions, has been, in this edition, omitted.

Familiarity of engineers with the Marks handbook and the wide acceptance which it has enjoyed



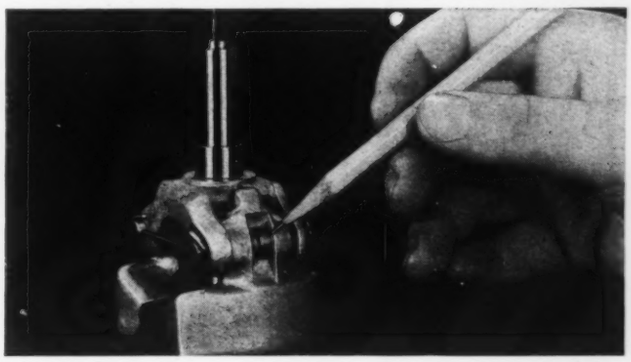
TORRINGTON NEEDLE BEARINGS *SIMPLIFY DESIGN,* REDUCE FRICTION FOR PIERCE GOVERNOR





"TORRINGTON NEEDLE BEARINGS ARE 'BLITZING' FRICTION LAG in many Pierce Governors where the critical demands of defense needs require friction-free operation," says Maynard L. Heacox, of the Pierce Governor Company. Pierce Governors are being used today to control power for defense in tanks, trucks, searchlights, field radio apparatus and in many other important applications such as that shown above on a LeRoi gasoline engine.

LOW INITIAL COST, EASY INSTALLATION and efficient lubrication are three of the many advantages obtained by Pierce Governor through the use of Needle Bearings on valve and rocker shafts. The precision-ground rollers and hardened outer race of these bearings form a self-contained unit that is speedily, inexpensively installed. And maintenance cost is low because lubricant is retained by the turned-in lips of the race.



"TO MEET RIGID WEIGHT AND SPACE LIMITATIONS, Torrington Needle Bearings are also used on the flyball weight pivots of Pierce Governors," adds Mr. Heacox. Here these compact bearings occupy no more space than ordinary bushings, yet substantially reduce oscillation friction.

FAVORABLE WEIGHT DISTRIBUTION, too, makes Needle Bearings ideal for weight pivot work, according to Mr. Heacox. The many linear inches of contact made possible by this bearing's numerous rollers provide an exceptionally high radial load capacity in proportion to its size.

Perhaps a small, lightweight, anti-friction bearing can give *your* product valuable advantages. Remember that Torrington Needle Bearings take no more space than bushings, yet provide exceptionally high load capacity with a minimum of wear and attention. Write for Catalog No. 109 and

find out the complete details about this compact, low-cost bearing. Our Engineering Department will be glad to answer any questions. For information on Needle Bearings to be used in heavier service, write our associate, Bantam Bearings Corporation, South Bend, Indiana, for Booklet 104X.

THE TORRINGTON COMPANY, TORRINGTON, CONN., U. S. A. · ESTABLISHED 1866

Makers of Needle and Ball Bearings

New York Boston Philadelphia Detroit Cleveland Chicago Los Angeles London, England

TORRINGTON NEEDLE BEARING

in the profession for a number of years necessitates no other comment than that the same high standard of accuracy and comprehensiveness has been maintained in this edition as in previous ones.

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Air and Gas Compression

By T. P. Gill; published by John Wiley & Sons, Inc.; 6 by 9 inches, 181 pages, cloth bound; available through MACHINE DESIGN *for $3.00 postpaid.*

Constituting a comprehensive reference to the subject of air and gas compression this book incorporates the result of recent researches into the property of gases with special attention given to the application of compressibility correction factors to the fundamental compression equations. Whereas such factors have been in use for some time in connection with the orifice measurement of gases, their application to gas compression is comparatively recent.

The author develops his subject from the perfect gas laws through single-stage compression, multistage compression, deviation from the perfect gas laws under extremely high pressure and through the flow and measurement of gases.

Twenty-nine tables are presented giving useful technical information on the properties of gases, compressor and vacuum pump characteristics, capacity of pipe lines, etc. Also 27 alignment charts are used which will facilitate the solution of most problems.

The author's effort to make this book a practical reference is demonstrated by the manner in which the discussion is, in most cases, related to specific compressors or vacuum pumps. Completely illustrated with cuts of actual compressors, pumps and their components as well as schematic drawings of illustrations with auxiliary equipment, the book is a convenient reference for the engineer engaged in problems concerned with the handling of gases.

□ □ □

Elementary Aerodynamics

By D. C. M. Hume, Group Captain, Royal Canadian Air Force; published by Sir Isaac Pitman & Sons Ltd., Toronto, Canada;; 5½ by 8 inches, 136 pages, cloth bound; available through MACHINE DESIGN *for $1.50 postpaid.*

Written for the specific purpose of supplying students and beginners in aeronautics with a concise and accurate outline of the essential science of mechanical flight, this book serves as an excellent introduction to research and engineering in the field of aerodynamics and should be of broad academic interest to designers.

Presented without involved calculations the primary purpose of the author is to convey a comprehension of aerodynamic phenomena without confusing the issue with involved theory. In the interest of logical exposition the characteristics of the medium, air, are discussed in relation to speed measurement, wind tunnel phenomena, etc. Force characteristics resulting from the use of various types of air foils are discussed in connection with the flat plate. The problem of stability also receives considerable attention with particular reference to the three normal axes. After an extensive study of the aerodynamic principles involved in airplane maneuvers, the subject of propulsion is treated with reference to airscrew theories and the relationship between power requirements and desired performance.

□ □ □

Elementary Mathematics for Engineers

By Sir Ambrose Fleming, Emeritus Professor of Electrical Engineering at the University of London; published by Chemical Publishing Co. Inc.; 5½ by 8½ inches; 110 pages cloth bound; available through MACHINE DESIGN *for $2:00 postpaid.*

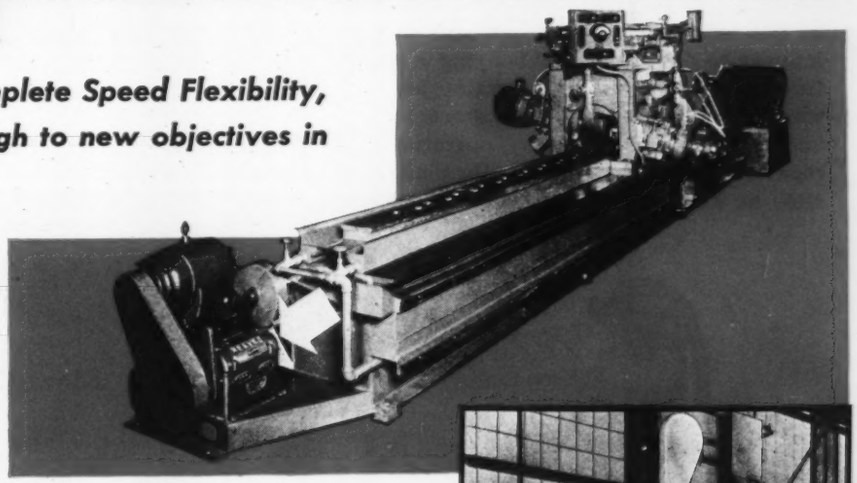
This book is a condensation into one convenient volume of ten major divisions of mathematics. Subjects covered include algebra, plane and solid geometry, differential and integral calculus, vector analysis and hyperbolic trigonometry. Extensive tables are appended which with the subject matter constitute a mathematical reference unsurpassed for convenience.

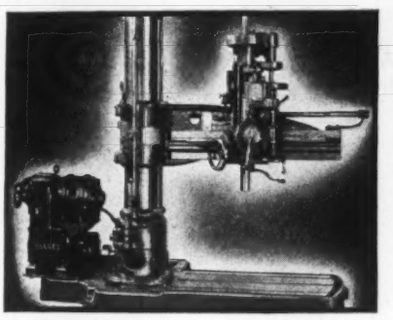
It's Design That Counts

—Courtesy N. Y. Herald Tribune

SPEED OF A *Machine* MAY BE AS IMPORTANT AS THE SPEED OF A *Tank!*

● ***When a machine has Complete Speed Flexibility, you can quickly break through to new objectives in defense production . . .***





DRILL PRESS EQUIPPED WITH REEVES MOTODRIVE

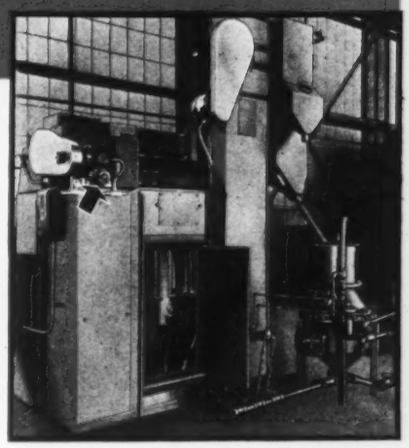
Size of drill, gauge and hardness of metal —*all* influence the speed at which a drill press should be operated, for best results. Presses with inadequate speed control are obviously limited in capacity and variety of work. On the other hand, the radial drill press as shown above, rebuilt by the Louis E. Emerman Co., Chicago, and equipped with a REEVES Vari-Speed Motodrive, is so versatile and flexible it is running continuously in a big armament plant. The "switch over" from one job to another is effected merely by turning a handwheel. The exact speed is so easily attained that REEVES-equipped machines are widely preferred by management and operators.

CUTS TIME FROM 60 HOURS TO 42 MINUTES

This spar milling machine (above) with REEVES Transmission and Electric Remote Control, built by Farnham Manufacturing Co., Buffalo, N. Y., now does in 42 minutes work that used to require 60 hours. On each spar milled, the section varies from end to end. By means of the REEVES Transmission the feed can be adjusted to conform to the various sections and optimum results can be obtained at all points, gradually and without stopping the machine. On high speed milling any jerk in the feed damages the cutters, which run at 3500 r.p.m. with feeds up to 240 inches per minute.

NEW RECORDS SET IN CLEANING SHELLS

Munition shells are blasted with abrasives to clean thoroughly exterior and interior surfaces and, naturally, the speed of the conveyor carrying the shells through the machine must be accurately timed for different shell sizes. This new American Foundry Equipment Shell Blasting Machine is accordingly equipped with a REEVES Vari-Speed Motor Pulley which provides any speed desired and new records for fast processing. No changing of gears, belts, or pulleys is necessary.



NEED HELP? This company maintains a nation-wide staff of factory-trained speed control engineers, located in strategic industrial centers. Their advice and counsel is offered, without obligation, to help speed our defense program. Write, wire or phone REEVES PULLEY CO., Columbus, Indiana.

★ ★ ★

REEVES PULLEY COMPANY

Recognized Leaders in the Specialized Field of Speed Control Engineering

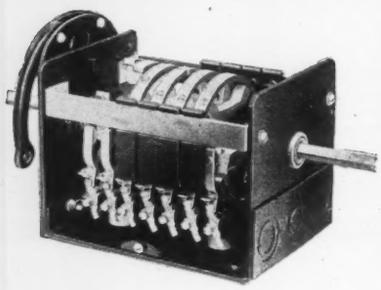
COLUMBUS, INDIANA

REEVES *Accurate Positive* SPEED CONTROL

New PARTS AND MATERIALS

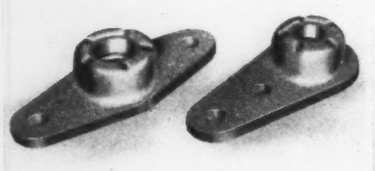
Small Drum Controllers Announced

DRUM controllers for small cranes and hoists, developed by Cutler-Hammer Inc., 315 North Twelfth street, Milwaukee, are small and compact in size and have several features of outstanding interest to designers. Embodying a new equalized torque principle, a rope operating lever eliminates sheave wheel, rope guard and external return spring, and provides smooth, easy operation even when rope is pulled at an angle. By making it impossible to whip drum from full forward to full reverse position, the new antiplug feature increases drum life. Reversing of drum can be done quickly but yet a definite time delay is required in the off position. The drums are available in self-centering rope lever, self-centering and non-self-centering radial lever types, for four or six speeds.



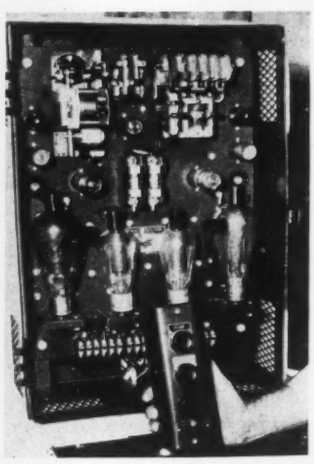
Fastening for Blind Mounting

FOR blind-mounting applications on general industrial equipment, Elastic Stop Nut Corp., 2332 Vauxhall road, Union, N. J., now offers a new vibration-proof fastening for removable plates used to cover hand-holes, access and inspection openings, etc. These anchor nuts are permanently riveted to the inside of the structure. The bolts, inserted from the outside, pass first through the removable plate, then through the structure into the stationary nuts. Available in a wide range of sizes, materials, and thread systems the nuts incorporate the self-locking feature, fiber locking collar which is an integral part of each nut. In such mountings, the bolts may be removed and replaced many times, the anchor nuts retaining their locking efficiency because of the resilient character of the fiber. The fiber is softer than the metal of the screw and cannot damage the threads or their plated surfaces. When the end of the bolt enters the unthreaded collar, its passage is resisted, thus automatically eliminating all play between threads of bolt and nut and establishing pressure contact of the threads.

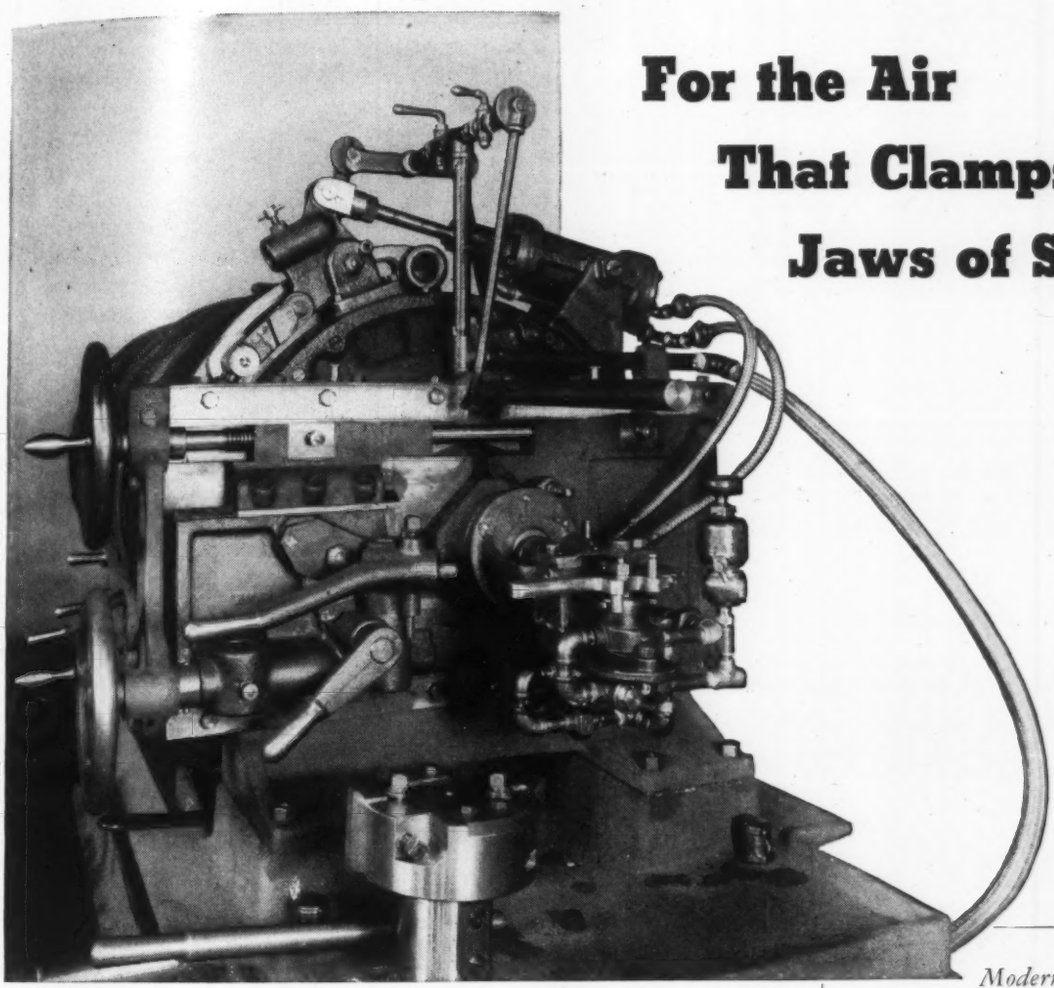


Electronic Motor Control

TO PROVIDE simple, stepless control of direct-current motors from alternating-current lines where a wide speed range is desired, General Electric Co., Schenectady, N. Y., has introduced a new electronic control system. With this control, flexibility of direct-current motors can be combined with the convenience of alternating power distribution. Simplified machine design, reduced space requirements and a saving of time in obtaining a wide speed range are some advantages of the system. The control, consisting of three separate units—a small control station, a transformer and a thyratron tube panel—provides in one equipment means for electronically starting, stopping, accel-



For the Air That Clamps These Jaws of Steel . . .



Modern pipe threading and cutting-off machine manufactured by the Landis Machine Co., Waynesboro, Pa.

THE JOB of the modern threading and cutting-off machine shown here is to "put the bite" on a daily diet of cold metal pipe. So, naturally, every part of it has to be plenty tough. And that's one reason why American Flexible Metal Hose was chosen for a *double* assignment on the machine. Parallel lengths of American Flexible Steel Tubing carry air under pressure to open and close the die heads. And American Type BD20 steel carries coolant to the cutting surface.

In both cases, the "garden hose" flexibility of American Metal Hose was an important reason for its choice. The pressure lines must take up a movement of about two inches every time the die heads open and close . . . while the coolant line must be free to move with the carriage of the machine as it operates.

At the same time, the coolant line, carrying a cutting oil, and the pressure lines, exposed to oil splash, had to be impervious to the deteriorating effects of the oil. Because its all-metal construction rules out "oil rot," here again American Flexible Metal Hose more than measures up to the mark.

Defense has drafted American Metal Hose and Tubing

. . . for lines on modern machine tools and for flexible connectors on all types of machinery now working overtime for national defense. Despite expanding plant facilities, it will not be possible for us to meet *all* civilian requirements. But *American* will continue to serve in old duties—and when peacetime requirements are again "first", *American* will still lead in the flexible connector field.

Write for Bulletin No. 40 illustrated below. It contains complete information on "American Seamless"—its properties, available forms, typical uses and methods of application. 41270

American Metal Hose

ANACONDA from mine to consumer

American Metal Hose Branch of The American Brass Company
General Offices: Waterbury, Conn. • *Subsidiary of Anaconda Copper Mining Co.*
In Canada: Anaconda American Brass Ltd., New Toronto, Ontario

For Defense Production Use TENSILASTIC Rubber Rolls

Tensilastic Rubber Rolls are doing their part during the defense program. They have replaced other "hard to secure" equipment in a great many plants. Possibly they can help speed up *your* production during the present emergency. For years Tensilastics have been producing in the paper, textile, tanning, steel, tobacco and hat industries. Write us about your manufacturing problems. We'll gladly give you the benefit of our experience regarding the adaptability of rubber rolls.

During the past 50 years we have manufactured rubber rolls and mechanical rubber products for a number of industries. Today we are also supplying rubber products to meet the demands of defense production.

For Protection Use Rubber

If you have equipment that requires protection against acids, fumes and other harmful elements, consider rubber. We rubber cover and rubber line tanks. We also rubber cover propellers, machine parts and a variety of other products. Write us regarding the advantage of rubber for protection.

AMERICAN WRINGER CO., Inc.

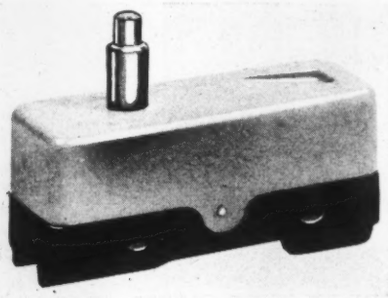
WOONSOCKET, R. I.

• TENSILASTIC •

erating and regulating the speed of a motor. The control station may be located accessible to the operator, allowing complete control from one location. The thyratron tube panel can be furnished in various types of enclosed cases such as those for corrosive or dusty atmospheres. Standard units cover motor sizes up to 5 horsepower, 230 volts. A single-dial control, mounted in a heavy-duty pushbutton station, covers complete speed range of motor, both above and below basic speed. For reversing service a standard magnetic reversing switch may be added.

Overtravel Type Switch

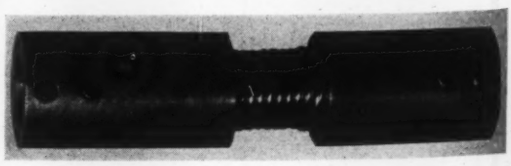
SIMILAR to its pin plunger type switch, the Acro Electric Co., 3179 Fulton road, Cleveland, has developed an overtravel type. Overtravel of at least



1/16-inch is provided, though the amount used for actuation remains at 1/1000-inch, as in the standard pin plunger type. Rolling spring principle is incorporated in the new switch which makes possible millions of positive, frictionless makes and breaks without failure. High operating frequency and contact pressure are provided. With a weight of approximately 1 ounce, and size of 1-15/16 x 11/16 x 27/32 inches, the switch is available in 10 amperes, 150 volt alternating current; 5 amperes, 250 volt, alternating current; and 3 amperes, 450 volts, alternating current, all rated for a maximum wattage of 1000. Pressure required is 3 to 14 oz.

Flexible Coupling Introduced

SIMPLE in construction, using a 4-layer, high carbon Swedish piano wire flexible core which is fused by high pressure into metal butt ends with various size bores, a new flexible coupling has been



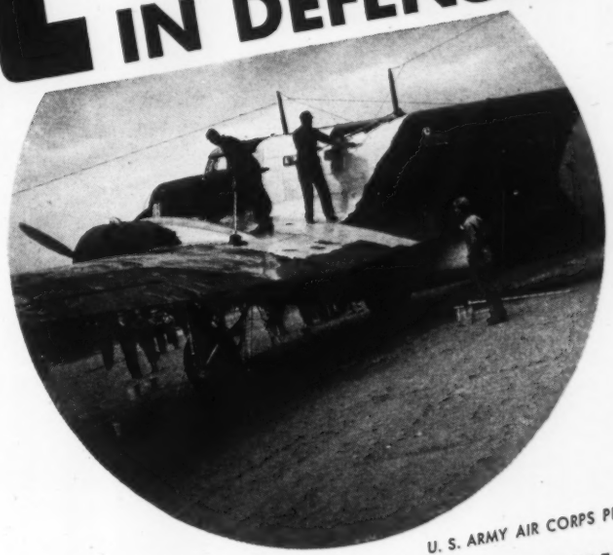
placed on the market by National Electric Manufacturers Co., 60 East Forty-second street, New York. Composed of only three fixed parts, the coupling can be used on reversing service without

NO. 3 OF A SERIES

ZINC IN DEFENSE-

PAINT SERVES DEFENSE IN:

Aircraft
Camouflaging
Cantonments
Combat Cars
Guns
Industrial Plants
Marine Equipment
Pontoon Bridges
Scout Cars
Shells
Troop Carriers—
And In Many Other Ways



U. S. ARMY AIR CORPS PHOTO

THE ELEMENTS ARE ALSO DESTRUCTIVE!

The primary requirement of many defense items is the ability to withstand the destructive forces of war. But there are other forms of attack to be reckoned with as well—rust, chemical corrosion, and the destructive forces of the elements on land and sea. The answer to these problems is paint. Uncle Sam is faced with the biggest painting job in the history of the country—a job in which zinc pigments are playing a vital part.

No man can estimate the amount of zinc pigments needed to complete this job, but the final figure will be a staggering one. The camouflage painting, shown above, is only a small part of the story. Everything from shells to ships, from cannon to cantonments has already been covered by hundreds of exacting Government paint specifications—requiring quantities of zinc sulfide, zinc oxide, lithopone, zinc dust and zinc chromate.

Listed above are typical uses for paint coatings in defense. Zinc pigments are doing the same job in these defense paints as they have been doing in the paint industry year in and year out—protecting property and improving sanitation, too, when that is a factor. It is the increased demand for each of the zinc consuming products required in the Defense Program which is making it difficult for non-defense users to obtain all of the zinc they would like to use. This is part of the price that must be paid for national security.

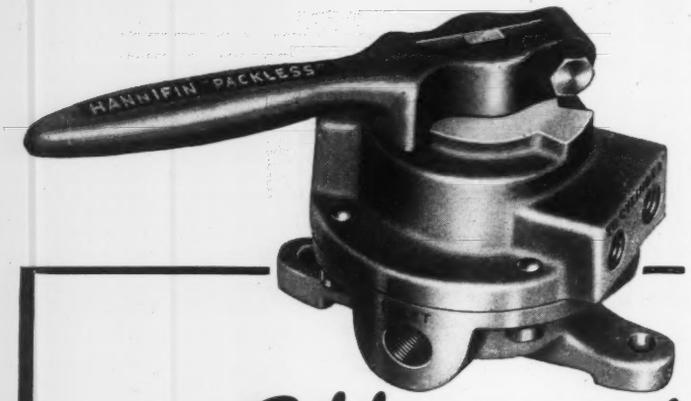
PAINT
DIE CASTING
CERAMICS
BRASS
METAL SPRAYING
GALVANIZING
PHARMACEUTICALS
NICKEL SILVER
NO. 1 HULL PLATES
NO. 2 RUBBER

"PAINT PROTECTS AMERICA"

ZINC PROTECTS PAINT

THE NEW JERSEY ZINC COMPANY

MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS



FOR *Efficient*
USE OF AIR POWER

Hannifin disc-type air control valve design has no packing—and no leakage or packing maintenance troubles. It provides the smooth, easy handling and positive control that is so necessary for continuous production with air operated equipment. In Hannifin Valves, control of air flow is by a bronze disc which is ground and lapped to form a perfect seal with the seat. Control is positive and accurate; wear is negligible, and, if necessary after long service, the seal can be restored by simply re-lapping.

Hannifin Air Control Valves are made in 3-way and 4-way types, hand and foot operated, spring return, heavy duty rotary, manifold, and electric models for control of single- or double-acting cylinders.

Write for Bulletin 34-MD with specifications of all types.

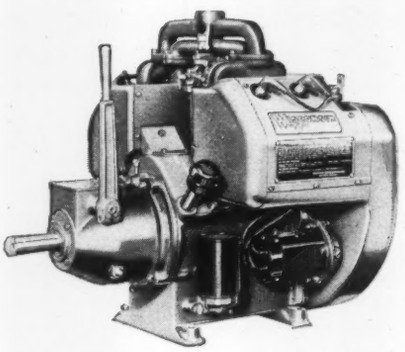
HANNIFIN MANUFACTURING COMPANY
621-631 SOUTH KOLMAR AVENUE • CHICAGO

HANNIFIN
"pack-less"
AIR CONTROL VALVES

changing position. It can be ordered to suit the shaft regardless of load, speeds or utility factor. The coupling absorbs shock and is constructed entirely of steel or brass. Both lateral and torsional elasticity are provided. Parallel and angular misalignment can be accommodated. Loads from ¼ horsepower to 25 horsepower can be handled at speeds up to 6500 revolutions per minute.

Heavy-Duty Gasoline Engine

RECENTLY introduced by Wisconsin Motor Corp., Fifty-third and Burnham avenues, Milwaukee, the Model VE-4 gasoline engine is a heavy-duty, air-cooled unit with a 22-horsepower rating. It is a compact, V-type, 4-cycle, 4-cylinder engine with a 3-inch bore, 3¼-inch stroke and piston displacement of 91.9 cubic inches. The engine develops 22 horsepower at 2600 revolutions per minute. Weight of the standard engine which comprises engine with impulse magneto, carburetor, flyball governor, fuel pump, oil filter, spark plugs, starting



crank and wires, is 285 pounds. Oiling system is entirely self-contained, with all parts automatically lubricated. A heavy, dynamically-balanced crankshaft is used, with long connecting rods and lightweight pistons, assuring smooth running at all speeds. Renewable valve seat inserts are used on both intake and exhaust. A large fan, cast in the flywheel, provides positive cooling by forcing a strong air blast across and around cylinders and heads. Engines are tested for efficient operation at 140 degrees Fahr.

Rotary Air Pump Developed

NEWEST addition to the line of vacuum pumps and compressors manufactured by Gast Mfg. Corp., Hinkley street, Benton Harbor, Mich., is a V-belt driven rotary air pump suited for operations such as paper feeding, lithographer's film plate holders, milking machines, and various other slow-speed applications. Specifically designed to meet a demand for a V-belt pump of good capacity in cubic feet per minute, providing medium vacuum service, Model 15F50 pump is slow and quiet in operation, and has a long life, ease of installation

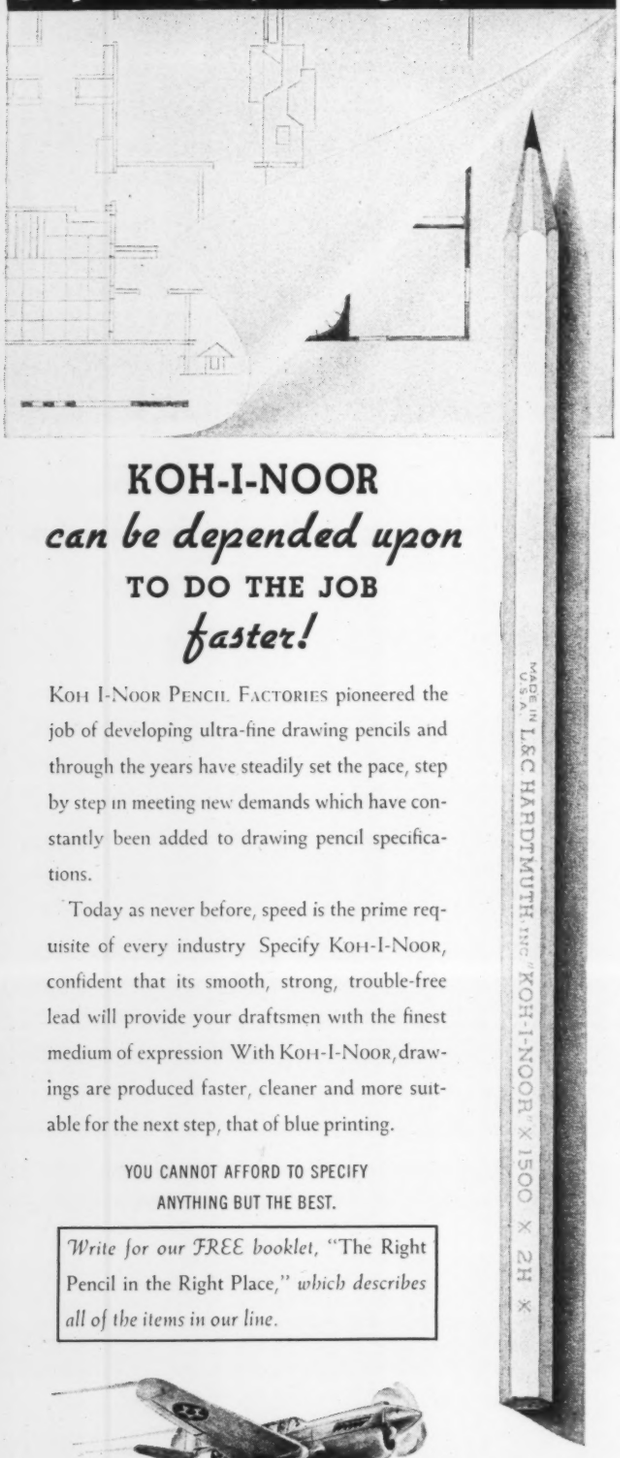
★ ★ ★

NICKEL

Practical answers to many questions about the selection, fabrication and uses of Nickel alloys are quickly available to you. This helpful information we have gathered, checked and condensed into convenient printed form. It is useful both to experienced men handling new materials or performing unfamiliar operations... and to new employees. This literature is available upon request. You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. Our engineers are offering timely suggestions to many vital industries during the present emergency. Your request for literature or personal consultation will receive our prompt attention.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

Speed Speed Speed



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can be depended upon
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faster!

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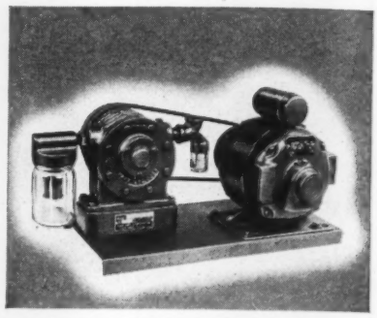
Koh-I-Noor Pencil Company, inc.
373 Fourth Avenue, New York

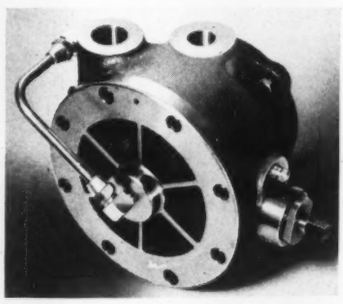
(regardless of shaft height or diameter) and low power requirement in proportion to the large air volume delivered. The pump is readily adaptable for operation with 1/4, 1/3, 1/2 and 3/4-horsepower



motors by simply changing the size of motor pulley. The pump sheave incorporates a cooling fan.

Dual Vane Hydraulic Pump

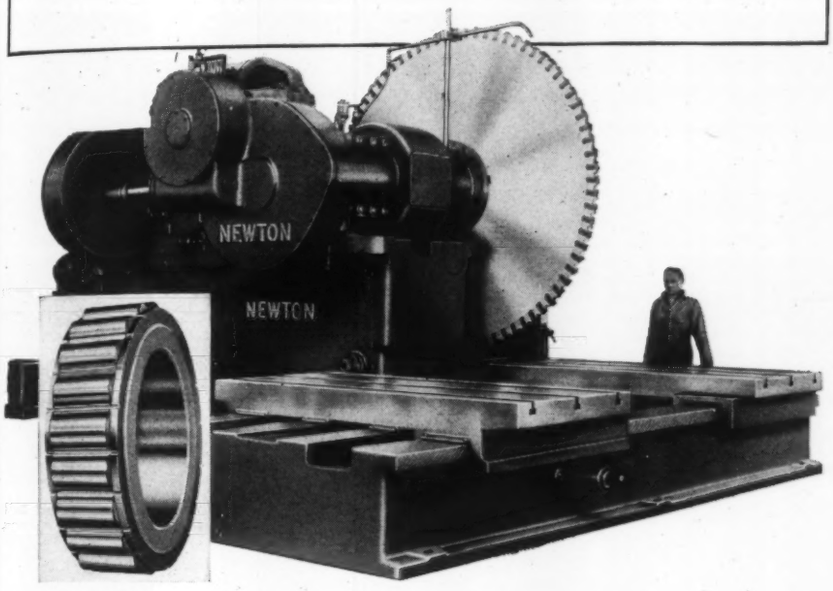
VARIABLE delivery hydraulic pumps of dual vane design, announced by Detroit Universal Duplicator Co., 221 St. Aubin, Detroit, employ a unique means of balancing the vanes so that overheating is eliminated, wear reduced, and pumps are virtually breakproof. Designed for continuous operation at high pressures the pumps can be used where possibility of line surges require "breakproof" pumps. Recommended for operation at



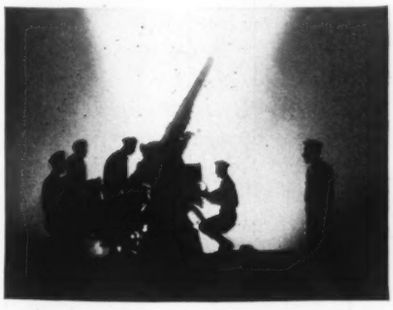
1250 pounds per square inch, the pumps can be used where periodic pressures are as high as 2000 pounds per square inch. Delivery is variable over two ranges; 4 to 0 gallons per minute and 8 to 0 gallons per minute. Increasing or decreasing rate of delivery is by means of an adjustment screw and can be done while pump is in operation. Each vane of the dual vanes employed in these pumps is beveled around its entire edge so that oil from the oil hole in the rotor can flow around all the edges of the dual vanes. Result is that a "back" pressure, variable to suit conditions, can be placed on the vanes from the stator side. In this way each set of vanes is held against the stator with only a portion of the total operating pressure of the pump. Another feature of the pumps is the method by which the split stator is arranged, en-

IN THE NEWS

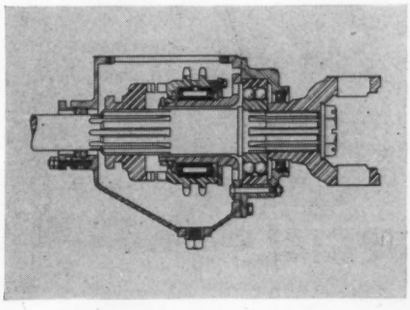
WITH BANTAM BEARINGS



TEN-FOOT CIRCULAR BLADE is a striking feature of this Newton Cold Saw Cutting-off Machine manufactured by Consolidated Machine Tool Corporation—probably the largest machine of its type ever built. Bantam Radial Roller Bearings were selected by Consolidated for use in this giant machine because of their compactness and high load capacity. Here is a typical instance of Bantam's skill in meeting novel design requirements.



BANTAM SUPPLIES ANTI-FRICTION BEARINGS of many sizes and types to meet the requirements of Industry and Government for defense production. Because of Bantam's broad experience in the design and application of every major type of anti-friction bearing, Bantam engineers are exceptionally well qualified to undertake the solution of new and difficult bearing problems. For advice on anti-friction bearings, TURN TO BANTAM.

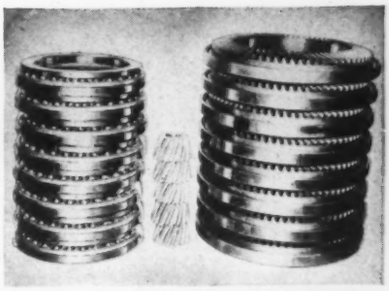


THIS COMPACT POWER TAKE-OFF is designed to take full advantage of the compact, space-saving features and high-capacity of Bantam's Quill Bearing. Built by Sterling Motors Corp. for use on heavy-duty Sterling trucks, it illustrates another application for this low cost anti-friction bearing. Completely self-contained, the Quill Bearing is admirably adapted to production-line assembly methods. For details on this unusual bearing, write for Bulletin B-104.

BANTAM BEARINGS

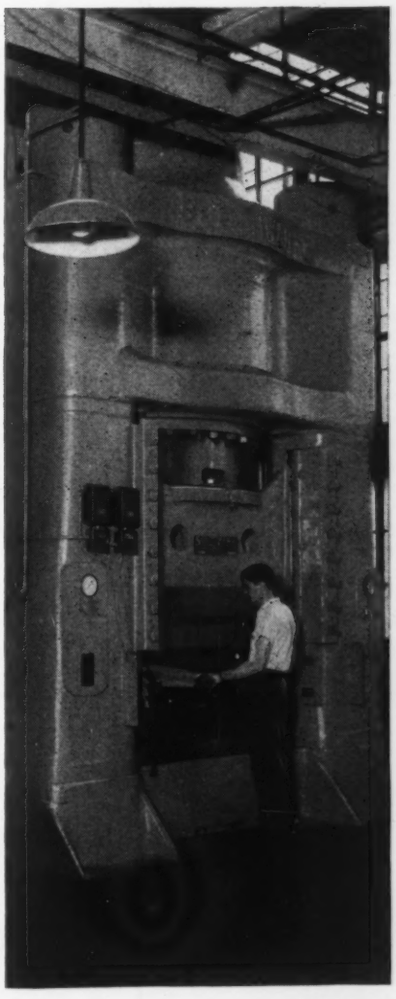
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION · SOUTH BEND · INDIANA



FOR HEAVY-DUTY WELL DRILLING, Pennington Signaling Core Barrel's 12¾" oil-bath rotary offers outstanding advantages in capacity and economy. Photo shows Bantam Ball Thrust Bearings and drive gears which give this rotary a capacity of 70 tons at 100 RPM, permit it to be operated continuously at 600 RPM when drilling. "Bantam Bearings are precision-made," says Mr. Harry Pennington, "and we could ask for nothing better than what you furnish. Our products are also precision-made to take advantage of Bantam's accuracy."

4000-TON FORMING PRESS built by Baldwin-Southwark is powered by two Oilgear Two-way Variable Displacement Pumps with a combined displacement of 143 gallons of oil per minute at pressures up to 3,000 pounds per square inch. Each pump rotor turns on large Bantam Radial Roller Bearings—7.0866" I.D. for front rotor bearings, 9.0551" I.D. for rear rotor bearings.



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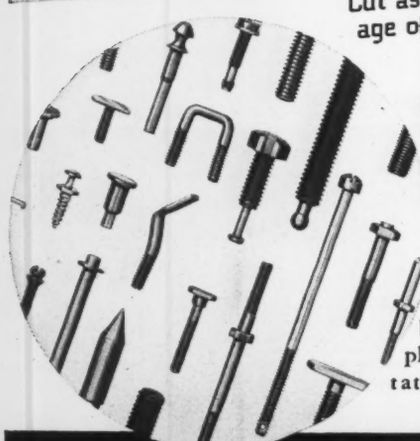
"LOCK-TITE" Screws U.S.PAT. NO. 2226491

The lock washer is part of the screw! A new, improved device for metal-to-metal fastenings that embodies in ONE unit all the locking features of washer and screw assemblies plus added economies. *Made to meet specific needs of user.*

HOLTITE-Phillips Recessed Head, Self-Centering SCREWS & BOLTS

Cut assembly costs an average of 50% and more.



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We have the most complete facilities for producing special parts and fastenings exact to specifications. Send blue prints or samples for prompt quotation.

CONTINENTAL SCREW COMPANY

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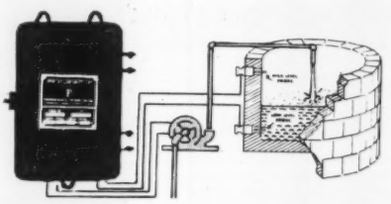
abling either or both halves to be moved to increase or decrease the delivery rate. Housing of the pumps is for flange mounting with adjustment screws at opposite sides. Vanes, rotor and stator halves are of hardened and ground steel, as is the splined driveshaft.

Electronic Level Control

USED for the control of water, milk, nitrates, sulphates, alcohol, distilled water, refrigerants, gasoline, etc., Photoswitch Inc., 21 Chestnut street, Cambridge, Mass., has introduced its new electronic liquid level control series P16. Complete equipment is available for single level indication and control, on and off pump-up and pump-down control at two levels, boiler feed water control and low level safeguards. For high and low



pressure and temperature requirements, probe fittings have been designed. Probes or electrodes are attached to the tank at levels representing the low point where pumping starts and the high level where pumping stops. When the level of the liquid falls below the lower probe, the level control starts the pump in operation and the tank fills. When the level reaches the upper probe, the fluid itself acts as a conductor of the small amount of current required for the operation of the level control which stops the pump. The probe circuit carries only milliamperes of current at extremely low voltage and can be used with practically nonconductive fluids.

Lubricant for High Temperatures

IN INDUSTRIES where there are problems of lubrication at extremely high temperatures, the announcement of Standard Oil Co. of New Jersey, 26 Broadway, New York, of its new lubricating oil will be met with interest. The oil lubricates and then vanishes without a trace and is developed to solve the old problem of lubrication under intense heat, such as is found in kiln cars, glass making machinery, annealing and baking ovens, working parts of die casting machines and various hot parts of machines in the metal industries. The oil is recommended for temperatures above 400 degrees Fahr. where it lubricates and while doing so evaporates completely, leaving surfaces clean. It is available in several viscosities, ranging from a light-bodied water-white liquid to a viscous, slightly turbid liquid which requires more than eleven hours

DEFY ERASURE-GHOSTS
with this new tracing cloth

Here is a tracing cloth that holds erasure scars at a minimum—that won't show water marks or perspiration stains. Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. Its new white color and increased transparency give you excellent drawing contrast and produce strong blueprints.

Let PHOENIX prove its virtues on your own drawing board. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

EST. 1867

KEUFFEL & ESSER CO.

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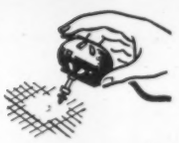
PHOENIX DEFIES MOISTURE GHOSTS

Perspiration and water splashes on ordinary tracing cloth create "ghosts" which reproduce on blueprints. PHOENIX Tracing Cloth withstands actual immersion in water for fully 10 minutes at a time! *Perspiration and water marks will not stain it!*

PHOENIX LESSENS SMUDGE GHOSTS

The new improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.



PHOENIX REDUCES ERASURE GHOSTS

Ordinary tracing cloths become scarred when erased... erased spots produce ghosts on blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

K&E

Phoenix

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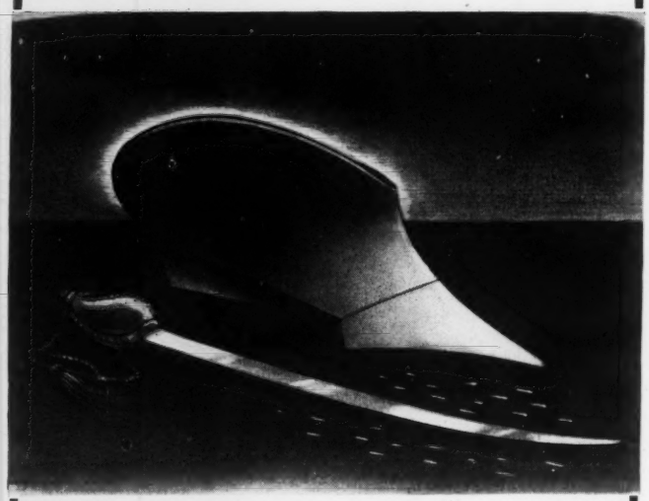
TRACING CLOTH

for pencil *and* ink

swords AND plowshares..



. . . guns *and* bread! Whatever the job, whether for war or peace, Arkwright tracing cloths need make no compromise with quality. Years of testing in Arkwright laboratories . . . years of insistence on highest quality materials and highest standards of manufacture have prepared Arkwright for any national emergency. Today, you can order Arkwright tracing cloths with the same confidence in quality . . . the same assurance of rapid delivery that has given Arkwright its recognized position as America's leading manufacturer of tracing cloth for over twenty years! Arkwright Finishing Company, Providence, R. I.

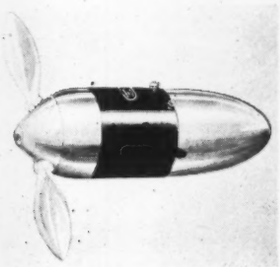
Arkwright

TRACING CLOTHS

for two ounces to flow through the orifice of a viscosity measuring device. The oil spreads to four or five times its original area, and remains longer on bearing surfaces under high heat. Another grade of oil is available, incorporating colloidal graphite, for use where oil cannot be reapplied before evaporation takes place.

Aircraft Generator Charging Units

LIGHTWEIGHT, wind-driven generator charging units have been introduced by Champion Aviation Co., Los Angeles, Calif. Specially designed and built for aircraft use, the unit is made of dural wherever possible. Electrical parts are of cadmium-plated brass. The generators are equipped with



voltage control and release to prevent over-charging and, on the four larger models announced by the company, the propeller position can be adjusted to carry maximum power for all variations of cruising speed. Six volt models of 6, 12 and 20 ampere capacity weigh only six, nine and thirteen pounds respectively. Twelve volt models of the same weight are available in 4, 8 and 15 ampere sizes.

Water Pump Seal Has Two Parts

INTRODUCED by Crane Packing Co., 1800 Cuyler avenue, Chicago, the new water pump seal has only two parts—bellows and spring. The bellows is of a synthetic rubber compound found to be superior for sealing services and not affected by grease, oils, salt water, alcohols or antifreeze solutions. It is installed partially compressed, ready for instant sealing. The unit is spring-driven and operates as a driving coupling. Seal does not touch or have sliding contact with the shaft and therefore rust, corrosion and deposit do not interfere with or reduce efficiency. The bellows connects two flanged ends with the spring placed in a fixed posi-

F-M MOTORS WITH THE COPPERSPUN ROTOR . . .

● *Now* is the time to give your motors a thorough physical examination. Can they be depended upon to stand up under today's greater demands? Find out *before* they fail . . . *before* they cause expensive delays.

Then *compare* your motors with Fairbanks-Morse Motors having the *Copperspun* rotor. These F-M motors set a new standard of performance . . . a standard that's in tune with today's production tempo.

They are unrivaled in ability to stand up under the most severe plugging and reversing service. Why? Because they are the *only* motors having rotors with windings centrifugally cast in one piece of SOLID COPPER.

And the characteristics of copper make it the ideal rotor material. Copper has high electrical and thermal conductivity (twice as good as aluminum), greater strength, and low thermal expansion.

If dependable power is important to your operations, investigate these superior motors now. Write Fairbanks-Morse & Co., Dept. L99, 600 S. Michigan Ave., Chicago, Ill.

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Copperspun
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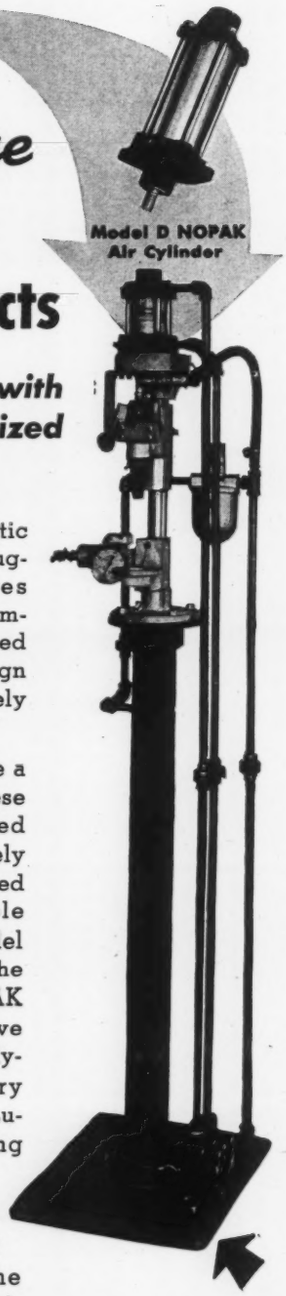
DIESEL ENGINES ELECTRICAL MACHINERY RAILROAD EQUIPMENT WASHERS-IRONERS STOKERS
PUMPS FAIRBANKS SCALES WATER SYSTEMS FARM EQUIPMENT AIR CONDITIONERS

Streamline Your Design Projects

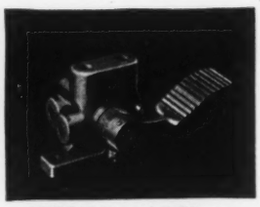
Plan New Machines with Available Standardized Units



For example, the Pneumatic Screw Driver illustrated suggests how NOPAK Valves and Cylinders may be combined with other standardized units to expedite the design and production of an entirely new piece of equipment.

Specially built to overcome a "dust explosion" hazard, these air-powered, air-controlled screw drivers consist largely of the following standardized units mounted on a simple base and pedestal:—A model "D" NOPAK Cylinder for the vertical movement; a NOPAK 4-way Foot Operated Valve for precision control; a "ready-made" Turbine for rotary power; Pressure Gauge; Lubricator; Standard Shafting and Piping.

Here, then, is a new tool developed with a minimum of design effort through the strategic adaptation of available parts and units. Similar applications of NOPAK Valves and Cylinders may prevent a design "bottleneck" in your engineering department, and help to speed the production of vital defense tools.



NOPAK 3- and 4-Way Foot Operated Air Control Valve

Write for Literature and Suggestions on Specific Problems

GALLAND-HENNING MFG. COMPANY
2752 S. 31st St. **Milwaukee, Wis.**

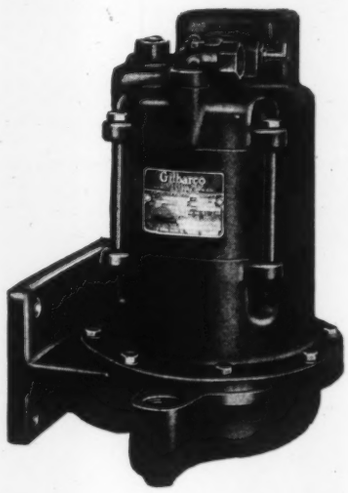
Representatives in Principal Cities

NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

tion against the inside shoulders of the flanged ends and holding serrated contact facings against the sealing washer on one end and driving base on the other. These facings are formed in a series of concentric grooves and flat-faced ribs, effecting seal with a suction action. Both ends of the seal are identical, permitting "blind-fold" installation. Because of the seal's ability to flex and compress as a unit, pressure variation, misalignment, fan thrust, torque or vibration set up by an unbalanced impeller, are automatically accommodated.

Centrifugal Coolant Pump

CENTRIFUGAL coolant pumps for machine tool service, announced by Gilbert & Barker Mfg. Co., Springfield, Mass., have a capacity of 13 to 15 gallons per minute, full flow through a ¾-inch discharge line. The pump, a ¼-horsepower explosion-resisting motor and the motor switch are built as an integral unit. No brushes or commutator are used in the motor, which has a notably low starting



torque. A positive mechanical seal which prevents any possibility of cutting oil or compound reaching the motor is located between the motor and pump. The pump delivers cutting oil or compound the moment the motor starts. There are no metal-to-metal contacts, making for smooth operation and long life and permitting handling of liquids charged with filings, small chips and abrasive impurities as large as .035-in diameter. The pump is attached by means of four large bolts in the mounting flange surrounding the inlet port.

Molded Fabric Bearings

DEVELOPMENT of special molded fabric bearings for crane track wheel, trolley and line-shaft service has been announced by The Gatke Corp., 228 North LaSalle street, Chicago. Lubrication of these bearings is much less critical and the bearings do not score journals. Even if lubri-

DRIVE POWER!

FAST striking tank columns depend on drive power to force an opening in enemy lines, or to repel an attack by enemy armored columns.

Drive power is essential in industry too, if we are to build a strong National Defense to insure a constant flow of arms material to our fast growing armies. Uninterrupted power performance of mechanical drive equipment in the machines you design, the elimination of costly "time-outs", is vital to the production for which those machines will be used.

Whatever your problems of speed reduction or mechanical power transmission may be, they can generally be solved economically by the application of an IXL Speed Reducer, Motorized Reducer, Agitator Drive, a Modified Standard Reducer, an Industrial Gear or Precision Gear.

Why not get in touch with us today? Engineering recommendations concerning the application of the equipment above to your requirements involves no obligation on your part.

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Sabotaged . . .

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RELAYS by GUARDIAN

Modern as tomorrow's airplane—Relays by Guardian must be up-to-the-minute because they're specified on the planes of tomorrow as well as today's Trainers—Fighters—Bombers—Tanks—for Transmitters—Turrets—Bombing Equipment—Fire Control—or practically every defense job you figure.

Do you need Gun Switch Handles—Turret Controls—Relays that weigh less than ½ ounce—Double Pole, Double Throw Control (Thumb-size, one-ounce weight)—Solenoids—or a two-pound Contactor to handle 1000 amp. surges?

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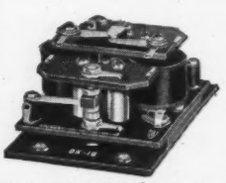
Planning for TOMORROW—there's a good chance we have your 194? control on the shelf right now! When the end of defense calls for increased sales in strongly competitive peacetime markets, volume will only come if you're ready to offer the most *fully automatic* equipment you can design TODAY.

Perhaps you've already begun. If so, we can help you. If not, a letter, blueprint or a visit to our plant will give you a big head-start on the field.



Series BK—16 Relay. Built to minimum tolerances and the most exacting requirements in production quantities for the U. S. Signal Corps.

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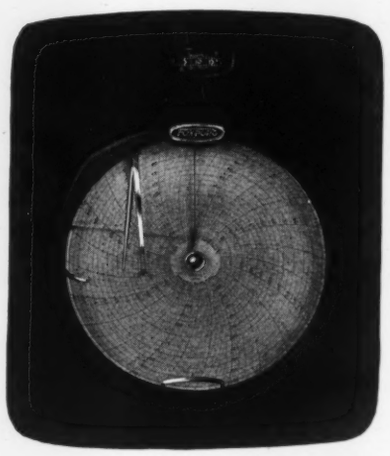
cation fails the journals are not damaged. The bearings are noncorrosive and withstand fumes, dirt, dust and neglect, and are available in finished dimensions in all shapes and sizes.

Automatic Controller Announced

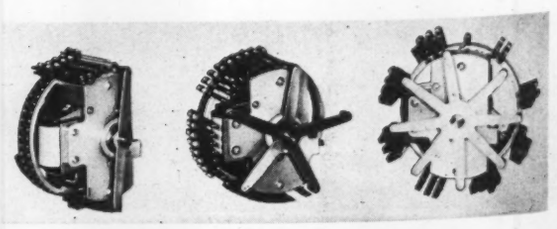
IN APPLICATIONS involving control of temperature, pressure, liquid level, or flow, the controller developed recently by The Foxboro Co., Foxboro, Mass., provides full pneumatic proportional control with automatic reset of the control point. In introducing the Model 30 controller, the company emphasizes the fact that the new features are principally refinements, for better appearance and still



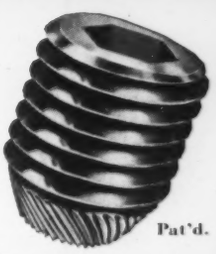
closer control. It appears in a new universal rectangular case. When panel-mounted, the instrument extends only ¾-inch from the panel surface. Door is recessed; hinges and hasp are flush with door surface. Replacing the customary two small gages, a dual pressure indicator can easily be seen through the rectangular opening in the door. When desired, interior illumination is readily provided. All operating adjustments are made from the front of the case, adjusting mechanisms for change of control point, throttling range, and reset resistance being easily accessible when door is opened.

Rotary Switch for Many Positions

AUTOMATIC rotary switches brought out by The Autocall Co., Shelby, O., were designed with the following exceptional features in mind: Heavy-duty type, any combination or number of circuits up to fifty, circuit position removable or



THE HEAD has it!



"UNBRAKO"

Knurled Socket Head Cap Screws

Yes . . . the head has it, and it's KNURLING—famous "Unbrako" feature for years and at no extra cost!

Today the speed-up advantages of KNURLING are being realized more than ever before. Dry or greasy fingers gear right to dry or greasy knurls and prevent annoying time-wasting slip—be it a job of assembling or adjustment. And the KNURLING also permits quick, easy locking of the screw after countersinking.

"UNBRAKO" Knurled Self-Locking Hollow Set Screws

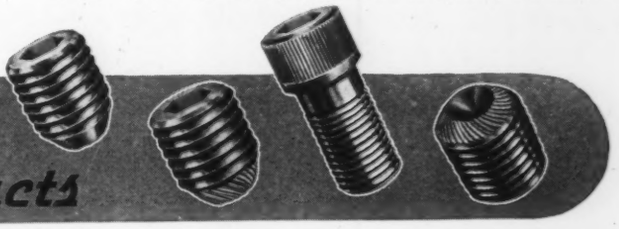
No less famous is the self-locking feature of "Unbrako" Hollow Set Screws . . . and once again it's KNURLING that does the trick by locking the screw firmly in place after having been pulled up with no more than average pressure. No matter how severe the vibration, you can count on the "Unbrako" Self-Locker to *stay set!* Yet it's easily applied or removed and can be used repeatedly.

Be sure to make your next order "UNBRAKO". You'll find it pays in many ways.

The KNURLING of Socket Screws originated with "UNBRAKO" years ago.

STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA. BOX 102
— BRANCHES —
BOSTON • DETROIT • INDIANAPOLIS • CHICAGO • ST. LOUIS • SAN FRANCISCO

Reg. U. S. Pat. Office
UNBRAKO Screw Products



HOW FAR CAN HE JUMP?

You can't tell how far a frog can jump by looking at him, and you can't tell how good a tracing cloth is by reading advertisements or by listening to a sales-talk.

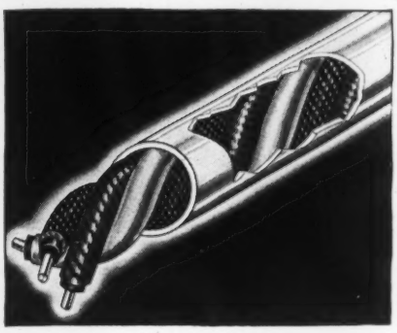
In the case of the frog, you give him a poke to make him jump — and you find out how good a jumper he is. In the case of tracing cloth, you put it to work in the drafting room — and in actual use, you find out how well it performs. That is the only evidence you can believe—and we ask you to make that test, because we know what you will find out. Of course, we think you will buy our product and that will be to our profit — but further than that, we think you will profit also. The test won't cost you one cent — just ask your dealer or write to us for free working samples of Micro-Weave.

The Holliston Mills, Inc.
NORWOOD, MASS.
BOSTON NEW YORK PHILADELPHIA
CHICAGO ST. LOUIS RICHMOND

replaceable, switch of homing or magnetic release type, and advancing mechanism jack connected for easy maintenance. The base consists of a cast aluminum frame as does the inner part of the switch. Springs of the contact "pile-ups" are actuated by bakelite rollers on the end of the operating arms of the switch. Contact assemblies are available in any combination of make, break or break-make (when energized) with maximum of 12 springs in one pile-up. Pile-ups can be bridging or nonbridging or a combination of both. Contacts will break at 5 amperes, 48 volts direct current; 1 ampere, 125 volts direct current; 5 amperes, 115 volts, alternating current maximum noninductive load. Overall size is 5⅛ inches in height, and 6 to 8 inches in diameter.

Metal-Shielded Wire Tubing

LIGHT-WEIGHT, metal-shielded wire, furnished by Precision Tube Co., 3824 Terrace street, Philadelphia, provides a new method of shielding insulated wire or wires with seamless aluminum or copper tubing, tinned or untinned. This permits maximum protection against electrical interference,



noise, corrosion, moisture, alkalies and mechanical damage. Metal shielded wire is available as a single conductor with an outside diameter of .018-inch to multicable types up to 1 inch outside diameter, with either aluminum or copper shielding, and with practically any number of wires. These can be obtained in exact lengths, multiple lengths or random lengths.

Tin Finish for Copper, Brass

APPLICABLE to all copper and brass surfaces, a new immersion tin finish has been introduced by the Alrose Chemical Co., Providence, R. I. It may be applied in ten seconds and can, in many instances, replace slow boiling methods of tin plating. Solution is prepared by dissolving sodium cyanide and paste supplied by the company in one gallon of boiling water. When cooled to room temperature no further heat is necessary; the material may be completely plated by immersion in the solution. Enamel and glass containers are used and work can be handled in baskets or on wire hooks. Being pure tin, the finish offers considerable corrosion resistance.

COMING IN ON THE BEAM

Powder Metallurgy makes possible unique properties in certain parts which actuate the automatic landing of airplanes by radio beam control. A single part may combine the properties of high grade iron at radio frequencies, and those of a good ceramic insulator at power frequencies.

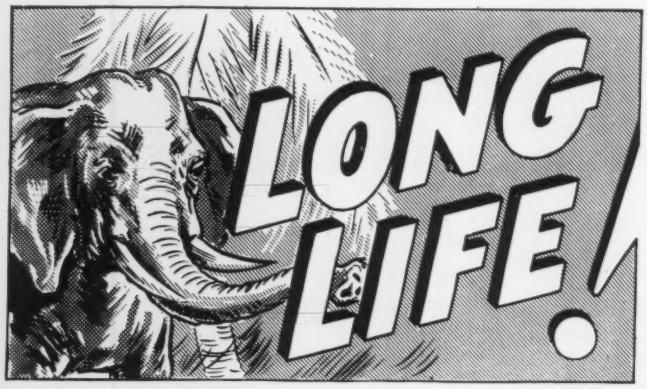
Here as in other instances, the special characteristics obtainable by powder metallurgy open the way to distinctly new designs in instruments or machines. This element of design is one of the primary factors in utilizing the advantages of the powdered metal product.

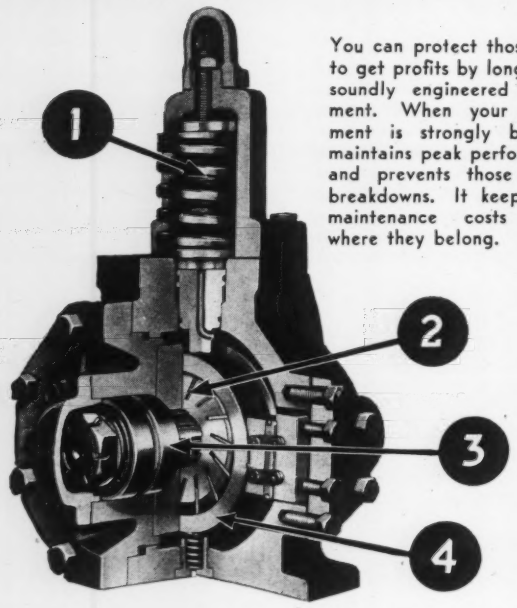
The "beam" which can guide expectations from this new method to a "safe landing" is the continued development and sharing of accurate knowledge by the designer, the metallurgist and the manufacturer of metal powders. Specifically, a knowledge of application requirements . . . of the properties of powders and their effect upon product and processing . . . of what can and cannot be done in the present stage of this technique.

As pioneer producers of metal powders, the service that we can render customers is based upon the solid ground of 25 years in developing and manufacturing powders of all metals, and cooperating in many of their most important applications.

METALS DISINTEGRATING COMPANY
ELIZABETH NEW JERSEY

METAL POWDERS SINCE 1916





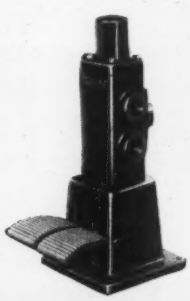
You can protect those hard to get profits by long lived, soundly engineered equipment. When your equipment is strongly built it maintains peak performance and prevents those costly breakdowns. It keeps your maintenance costs down where they belong.

Here are four reasons why RACINE Variable Volume Hydraulic Pumps are exceptionally long lived. They are important when maintaining continuous working pressures of 1000 pounds per square inch with deliveries of 12, 20, and 30 gallons per minute.

1. Shock absorbing governor automatically protects your equipment from hydraulic hammering by absorbing momentary shock pressures thus maintaining even pressure control.
2. Tilted hydraulically Balanced Vanes can not seize or stick and are polishers rather than gougers of the chamber ring. No wearing here!
3. Big Rugged Roller Bearings support the husky shaft, that extra strength to stand maximum loads day in day out.
4. True circle pressure chamber ring accurately finished imparts, smooth harmonic motion to the vanes. No chattering or uneven vane action to cause gouging.

These features mean low cost, long lived hydraulic power to you when you use RACINE Variable Volume Hydraulic Pumps. RACINE also has a full line of hydraulic balanced piston type valves from which to select the exact controls to meet your requirements.

Write for our free catalogs or better have one of our competent representatives located nearest you call. They will be glad to layout working circuits with you without obligation wherever our equipment can be profitably used. Write today!



RACINE TOOL AND MACHINE COMPANY
1773 STATE ST., RACINE, WISCONSIN

MEN *Of Machines*

ASSOCIATED with the automotive industry since his graduation in 1928, Wallace F. Ardussi has been placed in charge of research and development for Foote Bros. Gear and Machine Corp., Chicago. He is a graduate of the college of engineering, University of Michigan. Previous to becoming connected with Foote Bros. he had obtained a background of ten years engineering experience with Chrysler Corp. Here he progressed through the positions of research and development engineer, manufacturing and production research engineer, assistant to the president of the Airtemp division of Chrysler Corp., and sales manager of the Airtemp division.

RECENTLY announced by the directors of The White Motor Co., Cleveland, was the election of Forest S. Baster as vice president in charge of engineering. Mr. Baster, who has been with the company since 1936, was appointed chief engineer in 1937 in recognition of his work in designing the super power trucks which are manufactured by the company.

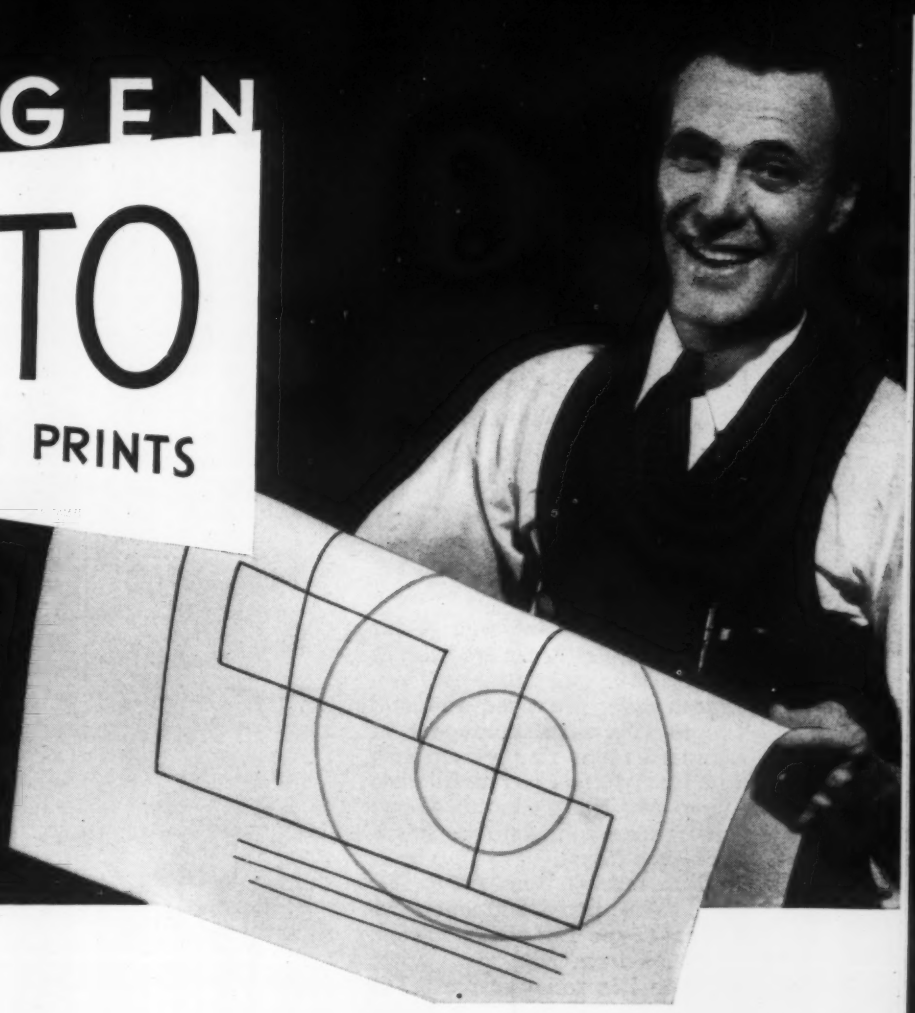
A native of Cleveland, Mr. Baster was graduated from Case School of Applied Science, and entered the automotive field in 1919, at Detroit, with

DIETZGEN

DIRECTO

BLACK AND WHITE PRINTS

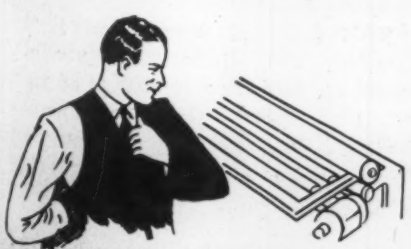
Save you TIME, TROUBLE and MONEY



No **PREMATURE FADING**

No **MISTAKES IN READING**

No **VARIATIONS IN QUALITY**



No **NIGHTLY WASH-UP**

No **RESTRICTED FOREIGN CHEMICALS**

ANY man who uses black and white prints will find important savings of his own time and energy with Dietzgen Directo prints. Besides this, there are important savings in other directions as well.

Dietzgen Directo prints have blacker, denser lines, and whiter, clearer backgrounds. They are easier to read, and reading is more accurate. There is less chance of any mistakes, less chance for mental upsets. Directo prints are more permanent than any black and white print you have seen before. They serve you longer, save you the trouble, cost and time of making new prints prematurely. Your operator doesn't have to worry about variations in development speed. Directo prints are of uniformly high quality *always* and Directo paper is *faster* than your operator can work. Still another important saving: the developing solution won't deteriorate. You don't have to clean your machine daily, don't have to rebottle the solution. Simply leave the solution in the machine and add to it as it is used up. No discoloration, smearing or fading.

And this unique and exclusive Dietzgen process uses all domestic chemicals. A dependable source of supply is assured, and *you* can depend on always getting highly satisfactory results. Try Directo prints and see the savings at once. A postcard will bring you a DEMONSTRATION of all these points of superiority . . . without cost, fuss or obligation.

EUGENE DIETZGEN CO.

Chicago • New York • Pittsburgh • San Francisco • Milwaukee
Los Angeles • Philadelphia • Washington • New Orleans
Dealers in All Principal Cities

DIETZGEN

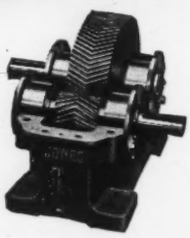
DIRECTO

TRADE MARK

THE *SUPERIOR* BLACK AND WHITE DIRECT PRINT PROCESS

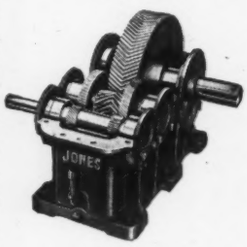
SINGLE!
DOUBLE!
TRIPLE!

—every type of
Herringbone Speed Reducer
that you might need



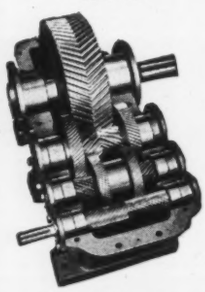
Single Reduction
Type SH

JONES Herringbone Gear Speed Reducers are built in a wide range of ratios and ratings to cover every requirement. Single (Type SH) reducers in standard ratios range from 1.25 to 1 up to 11 to 1 in ratings from 1.3 to 440 H.P. Double (Type DH) reducers are built in standard ratios from 10.9 to 1 up to 72 to 1 in ratings from 0.5 to 275 H.P. The triple reduction reducers (Type TH) cover a range of ratios from 86.9 to 1 up to 355.8 to 1 in ratings from 0.3 to 78 H.P.



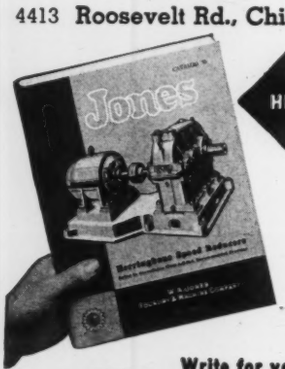
Double Reduction
Type DH

All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Cast iron bases are available for all variations of motor assembly. Liberal stocks are carried to facilitate shipments.



Triple Reduction
Type TH

W. A. JONES FOUNDRY & MACHINE CO.
4413 Roosevelt Rd., Chicago, Ill.



HERE'S THE LATEST INFORMATION
about the application of Herringbone Reducers

This new 128-page catalog of Jones Herringbone Reducers presents a vast amount of data relating to Herringbone Reduction Units. Illustrations show a broad range of herringbone reducer applications and the technical information shows how to select reducers for all conditions of service in accordance with the A.G.M.A. recommended practice.

Write for your free copy of this valuable treatise

Since 1890
Jones

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS
CUT AND MOLDED TOOTH GEARS — V-BELT SHEAVES
ANTI-FRICTION PILLOW BLOCKS — PULLEYS
FRICTION CLUTCHES AND TRANSMISSION APPLIANCES

Packard Motor Car Co. Thence he became connected with Lycoming Mfg. Co., Williamsport, Pa., where he was chief engineer. He left this organization to become associated, as mentioned, with The White Motor Co. in 1936.

VALUABLE background in the alloy steel field amply qualifies W. E. Griffiths for his new post as manager of Allegheny Ludlum Steel Corp. newly-created development engineering department. Mr. Griffiths studied at Mount Union College and Wooster University, and graduated from Ohio State university with a S. B. degree in metallurgical engineering in 1923. He began his career as a metallurgist with the Union Carbide and Carbon Research Laboratories 18 years ago, where he specialized in stainless steels. Later he held important metallurgical positions with the Duraloy company and the Central Alloy division of Republic Steel. For a paper he presented, with E. C. Bain, on chrome-iron-nickel alloys he was awarded the Robert W. Hunt prize by the American Institute of Mining and Metallurgical Engineers. During the eight years prior to his association with the Allegheny-Ludlum company, he handled engineering and sales promotion of stainless and other alloys for Carnegie Illinois. His new department has been set up to assure full attention to developments which have passed the research laboratory stage but which are not yet ready for commercial introduction.

♦

H. G. SMITH, formerly chief engineer of the automotive division, has been promoted to executive engineer in charge of engineering of automotive and industrial division and radial diesel division, Buda Co., Harvey, Ill.

♦

ROBERT E. BRESSLER has been elected vice president and general manager of Kol-Master Corp., Oregon, Ill., in addition to his duties as chief engineer. He was formerly a consulting engineer in Chicago and is the inventor of the Kol-Master automatic stoker for domestic and industrial uses.

♦

DR. JESSE E. HOBSON has been named director of the engineering department, Illinois Institute of Technology, Chicago. He had been in charge of application engineering on electric power equipment, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. In his new position he will teach senior and

(*Continued on Page* 116)

There is a **MORSE CHAIN DRIVE**

TO MEET YOUR REQUIREMENTS

Morse Silent Chain drive capacities start from 3/16" pitch for fractional h.p. drives and graduate up to 3" pitch for drives of 5000 h.p.

SILENT OR ROLLER— LARGE OR SMALL

Whether your drive requirements be silent or roller chain, involving fractional or thousands of horsepower—there's a Morse Chain to fill your specific needs more efficiently and economically. Today, power for production is precious. Inefficient drives waste power, reduce machine production. Insure against such "sabotage" by transmitting power without slip at constant (99.4%) efficiency with Morse Silent and Roller Chain Drives.

Morse Silent Chain speed and length changes are easily made—no need to dismantle machine.

Morse Roller Chains with solid rollers are interchangeable with all other standard round pin roller chains—available in single and multiple widths.

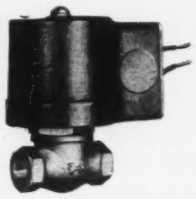
Learn how you can use Morse Silent and Roller Chain Drives to advantage—consult the Morse man in your territory.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

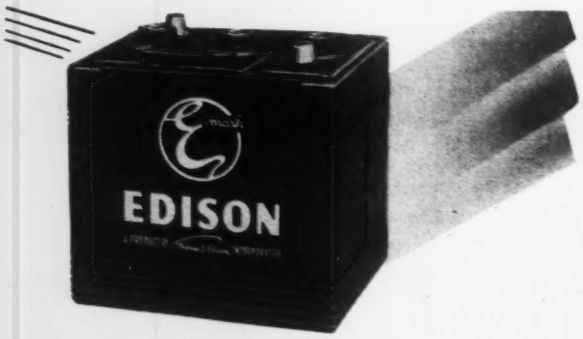
MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

WHEN YOU NEED A *better* SOLENOID VALVE *remember this report . . .*



Name of Company:	Thos. A. Edison Inc. Emark Battery Division
Address:	Kearny, N. J.
Products Manufactured:	Electric Storage Batteries.
Type of Valve:	PIX – High Speed.
Description of Service:	
Length of time valve has been in service:	Three years.
Approximate frequency of operation:	30 per minute.
Total number of operations to date:	Over 33,700,000.
Details regarding function that valve performs:	Feeding cold water to plate moulds.
Operating pressure and medium that is being controlled:	75 pounds.
Outstanding Features:	These valves replaced "— —" Valves which fell to pieces in two months.



When you have a perplexing problem involving the automatic or remote control of steam, air, liquids or gases, remember that there are more than fifty types of solenoid valves in the complete line of Asco Valves. One of them will meet your every requirement—effectively and economically.

Write for new Catalog 149

Automatic Switch Co.

49 EAST 11th STREET, NEW YORK, N. Y.

TELL US WHAT YOU WISH TO ACCOMPLISH

12—AS-2

(*Continued from Page* 110)

graduate courses in power system engineering, in addition to organizing and directing the electrical engineering course.

♦

DR. H. W. GILLETT, chief technical advisor, Battelle Memorial institute, Columbus, O., has accepted the invitation of the Institute of British Foundrymen to present the fifth Edward Williams lecture in 1942. The lecture was founded by C. E. WILLIAMS of South Wales, a past president of the institute. Dr. Gillett is the first American to be so honored.

♦

E. E. WARE, vice president of Sherwin-Williams Co., Cleveland, and for many years technical advisor to the president of the company, has been made head of the Sherwin-Williams Defense Corp., which will build and operate a shell-loading plant near Marion, Ill., for the War department.

♦

W. H. SPOWERS JR., for many years a consulting engineer specializing in galvanizing, has been appointed lieutenant commander in the United States Navy, and ordered to active duty in the Bureau of Ships, Washington. He is author of the book, *Hot Dip Galvanizing Practice.*

♦

E. R. JACOBY, technical director of engineering at Muskegon, Mich., plant of Continental Motors Corp., Detroit, has been transferred to Detroit to assist in Wright aircraft engine production.

♦

CHARLES BEHANNESY has joined the engineering staff of Rowe Radio Research Laboratory Co., Chicago, and will assist in research work.

♦

KENNETH R. BLAKE, who has had wide experience as consulting engineer and technical advisor in the development of new machinery, has been appointed chief engineer of the Kaydon Engineering Corp., Muskegon, Mich., manufacturers of special bearings and equipment.

♦

DR. EDWARD E. MINOR JR., research and development engineer of The Glenn L. Martin Co., has been named chairman of the committee on air transportation of the American Institute of Electrical Engineers, according to D. C. PRINCE, newly-elected president of the A. I. E. E.

♦

L. W. WALLACE has joined the staff of The Trundle Engineering Co., Cleveland, as vice president. He formerly was a research and management engineer.

♦

ALEX TAUB, designer and development engineer for Vauxhall Ltd., British subsidiary of General Motors Corp., has been appointed by O. P. M. to assist the automobile industry in shifting its facilities from passenger car to defense production. Previous to his Vauxhall connection and to being a member of the British Purchasing commission on a special mission in connection with aircraft engines, Mr. Taub was chief engine designer for Chevrolet for twelve years.

♦

H. H. ROTHROCK, formerly head of the industrial engineering department, University of Pittsburgh,

SELF LUBRICATING BRONZE BEARINGS

JOHNSON BRONZE

Ledaloyl

SUBSTITUTION
offers an unusual opportunity to IMPROVE

★ As the big job of arming the nation strains the resources of the country, many manufacturers are finding it necessary to seek substitutes in the production of their product. This does not necessarily mean a compromise with quality . . . rather, it offers an unusual opportunity for improvement.

Consider the use of Johnson LEDALOYL, a patented, self-lubricating bronze . . . the newest development in powder metallurgy. Within the past year LEDALOYL has supplemented small but important parts formerly made from zinc . . . steel . . . other metals and materials. In practically every case there was a distinct improvement in performance . . . longer life . . . economy.

An exclusive process of PRE-ALLOYING the basic materials of LEDALOYL provides uniform structure . . . uniform strength . . . dependable lubrication . . . the addition of lead as an integral part. These are but a few of the many factors that contribute to the unusual performance of LEDALOYL. Write today for complete details.

New Catalogue

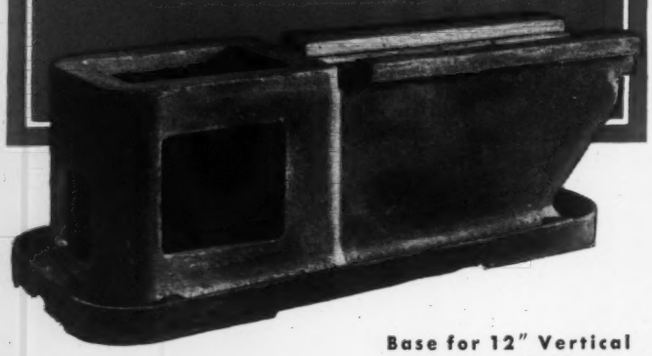
Listing over 2000 sizes of Johnson LEDALOYL for which we have tool and die equipment. This includes plain, flanged and self-aligning bearings. Write for a copy.

PRODUCTS
CAST BRONZE BEARINGS
CAST BRONZE GRAPHITED
SHEET BRONZE BEARINGS
SHEET BRONZE GRAPHITED
BRONZE and BABBITT BEARINGS
STEEL and BABBITT BEARINGS
STEEL and BRONZE BEARINGS
LEDALOYL
SELF-LUBRICATING BEARINGS
ELECTRIC MOTOR BEARINGS
AUTOMOTIVE BEARINGS
BRONZE BARS
BRONZE CASTINGS

JOHNSON BRONZE COMPANY
Sleeve Bearing Headquarters
525 S. MILL STREET NEW CASTLE, PENNA.

SALES OFFICES AND WAREHOUSES
ATLANTA BALTIMORE BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DALLAS DETROIT KANSAS CITY LOS ANGELES HOUSTON
MINNEAPOLIS NEW CASTLE NEW YORK CITY NEWARK PHILADELPHIA PITTSBURGH PORTLAND ST. LOUIS SAN FRANCISCO SEATTLE

For Machine Tool Castings
use ABSCO
MEEHANITE



Base for 12" Vertical Shaper—An ABSCO Meehanite Casting.

We make ABSCO Meehanite Castings to meet your specifications for the application desired

The Meehanite production methods permit pre-determination of these qualities and provide control of every step of the manufacturing process. Meehanite provides casting qualities never obtainable before.

Consult us about Your Problems

Send for Bulletin 9 "Meehanite, The Metal for Machine Tool Castings." It lists the controllable physical characteristics, illustrates and describes the application of Meehanite to this exacting work.

THE AMERICAN BRAKE SHOE AND FOUNDRY COMPANY

FOUNDRY
MAHWAH
NEW JERSEY

OFFICES

has assumed his new duties as assistant to the chief industrial engineer, Carnegie-Illinois Steel Corp., Pittsburgh. He has been with the faculty of the University of Pittsburgh as professor and head of the department of industrial engineering since 1933.

♦

MEADE BRUNET has recently been elected as one of the vice presidents of the RCA Mfg. Co. Mr. Brunet, who has been connected with the company since 1919, will continue his present duties as manager of the engineering products division, including government business.

♦

JOHN M. LESSELS and CHARLES W. MACGREGOR are joint recipients of the Louis E. Levy medal, awarded by the Committee on Science and the Arts of the Franklin institute in recognition of their paper entitled "Combined Stress Experiments on a Nickel-Chrome Molybdenum Steel." Both are associate professors in the department of mechanical engineering, Massachusetts Institute of Technology.

♦

LELAND H. GRENELL has been engaged by Battelle Memorial institute, Columbus, O., for research and development work in the new products research of the Institute. An important part of the work is the development of improved alloys of copper for industrial application. Mr. Grenell, a graduate in metallurgical engineering of Pennsylvania State college, has for the past five years been connected with the process engineering and materials development division at the Frigidaire company.

♦

H. C. MERRITT, vice president, Allis-Chalmers Mfg. Co., Milwaukee has been awarded the Cyrus Hall McCormick gold medal. This recognition was given Mr. Merritt for "exceptional and meritorius engineering achievement in agriculture" by the American Society of Agricultural Engineers.

♦

C. M. MARATTA has been made chief works engineer, succeeding the late W. C. MAKLEY, of Timken Roller Bearing Co. WALTER F. GREEN, a member of the company's engineering department since 1935, has been named assistant works engineer, and PUTNEY L. WRIGHT, with Timken since 1938, will be plant engineer.

♦

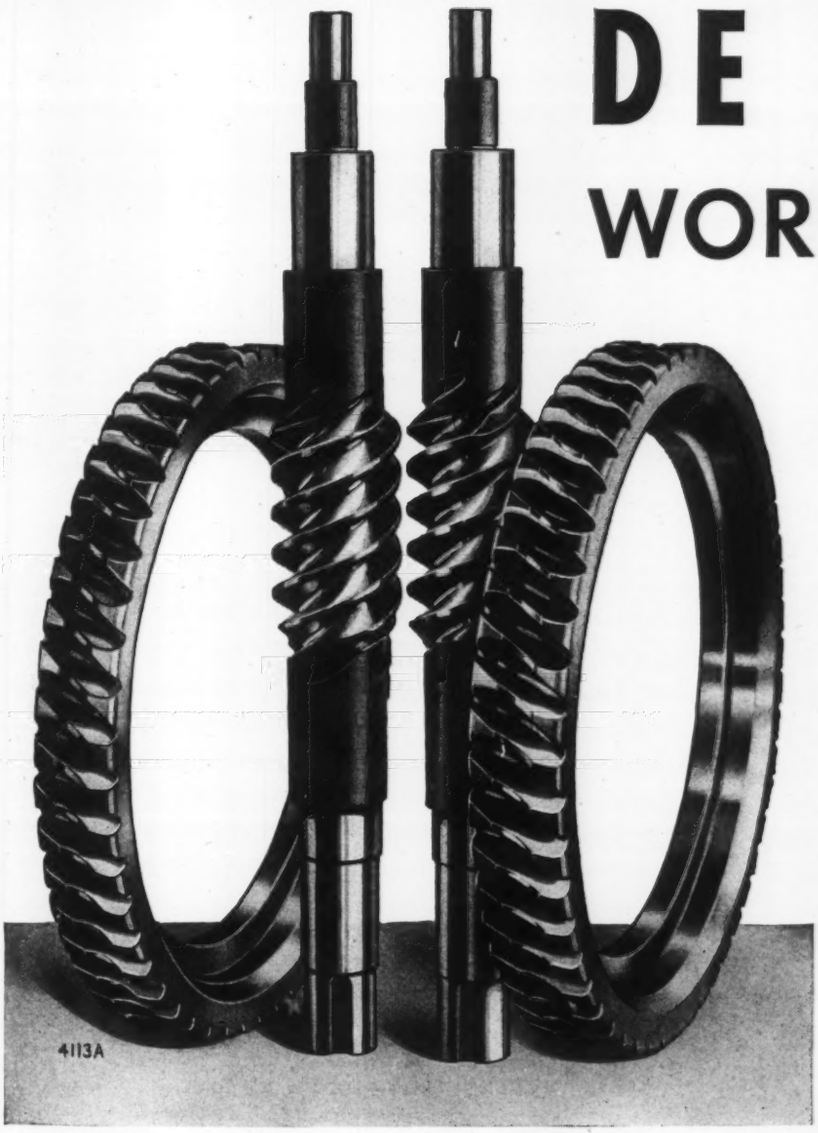
R. J. MINSHALL, vice president and director of Boeing Aircraft Co., Seattle, has resigned recently to become president of Pump Engineering Service Corp., Cleveland. He has been with Boeing since 1919 in engineering service.

♦

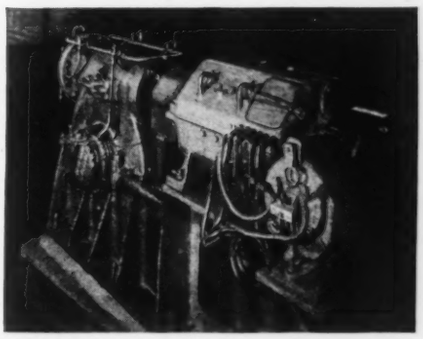
FELIX L. YERZLEY, for over five years physicist of the rubber chemicals division, E. I. du Pont de Nemours & Co. Inc., is now with the engineering department of the Pioneer Instrument division of Bendix Aviation Corp. He has been an active contributor to the programs of the American Society of Mechanical Engineers, American Society for Testing Materials and Society of Automotive Engineers.

Settle the drive question—specify

DE LAVAL WORM GEARS



Supplied either as **sets** to be built into your own machines or as **complete speed reducers,** including housing and bearings.



Hot bloom transfer drive, incorporating De Laval worm gear set.

Hot bed pusher drive, incorporating De Laval worm gear set.

The De Laval Worm Gear has fewer moving parts than has any other form of reducer, is highly efficient, and is exceptionally strong and reliable.

It is produced from the most suitable materials by precision methods and equipment and has the backing of a long established builder of first-class power machinery.

State operating characteristics of the power input unit and the nature of the load and ask for Publication W-1125.

DE LAVAL WORM GEAR DIVISION
of the De Laval Steam Turbine Co., Trenton, N. J.

MANUFACTURERS OF TURBINES STEAM, HYDRAULIC. PUMPS CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, CLOGLESS, SELF-PRIMING CENTRIFUGAL BLOWERS and COMPRESSORS. GEARS WORM, HELICAL and FLEXIBLE COUPLINGS

ISOLATE

VIBRATION AND NOISE

WITH GOOD

Felt

quickly and economically

Data Sheet No. 10 Tells How!

Vibration is destructive. It is costing you money for repairs to machinery and buildings. Noise is costing you money in lowered efficiency of workmen. Isolation can reduce, perhaps eliminate, these expenses.

Under machines exerting less than 50 lbs. pressure per sq. ft. the proper felt isolation will decrease vibration and noise substantially.

Amfelt Isolators placed under each leg of a machine or at each corner of a flat bed provide *economical* and *effective* isolation, and can be installed with a minimum of interruption to operation.

Practical and useful information to assist you in the selection and application of Felt for the isolation of small machinery is given in Data Sheet No. 10. Please send for a copy, on your company letterhead.

American Felt Company

TRADE MARK

General Offices: GLENVILLE, CONN.

Sales Offices at New York — Boston — Chicago — Philadelphia — Cleveland — Detroit — St. Louis — San Francisco

Plants at Glenville, Conn., Newburgh, N. Y. Franklin, Mass.

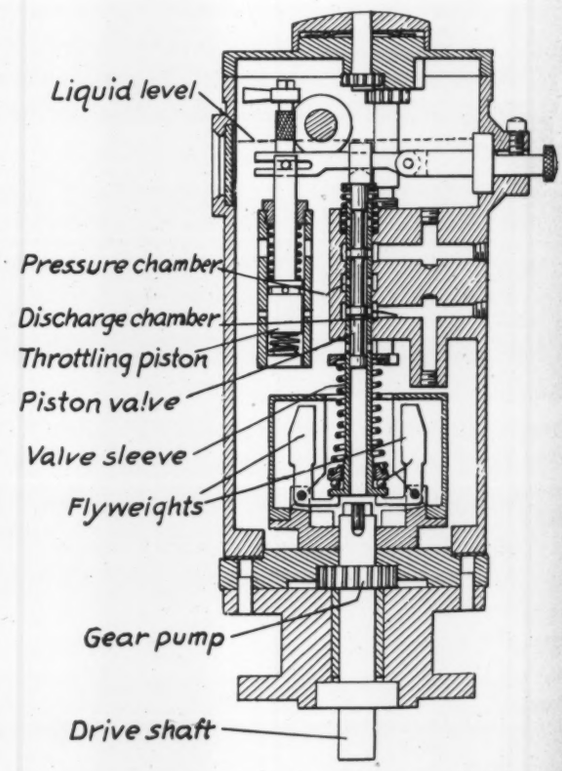
Cutting Shops at Port Chester, N. Y. and Detroit, Mich.

PRODUCERS OF FINEST QUALITY PARTS FOR OIL RETAINERS, GREASE RETAINERS, WICKS, DUST EXCLUDERS, GASKETS, INSULATING FELTS, CHANNEL FELTS, UPHOLSTERY RISER STRIPS, BODY SILENCING PARTS, DOOR MECHANISM GASKETS, AND BODY POLISHING WHEELS

Noteworthy PATENTS

Flyweights Immersed in Oil

GOVERNING of prime movers such as internal combustion engines which are subject to wide speed variation with loads is usually accomplished by controlling the fuel supply. Consequently for each change of load the governor must throttle at an entirely new position. If a simple centrifugal type of governor is used continuous fluttering or hunting is experienced. This condition is aggravated by the cyclic impulses transmitted to the governor from the engine by the interconnecting shafting. Assigned to the Woodward Governor Co. is a patent disclosing a governor incorporating a throttling range for accommodating



Governor automatically resets itself to adjust speed to changing load conditions without hunting

the speed to changing load conditions as well as a dashpot control on the centrifugal flyweights to mitigate their response to vibratory power impulses.

The entire governor housing is filled with fluid. The centrifugal weights are used only to control a piston slidevalve. Thereafter the entire governing

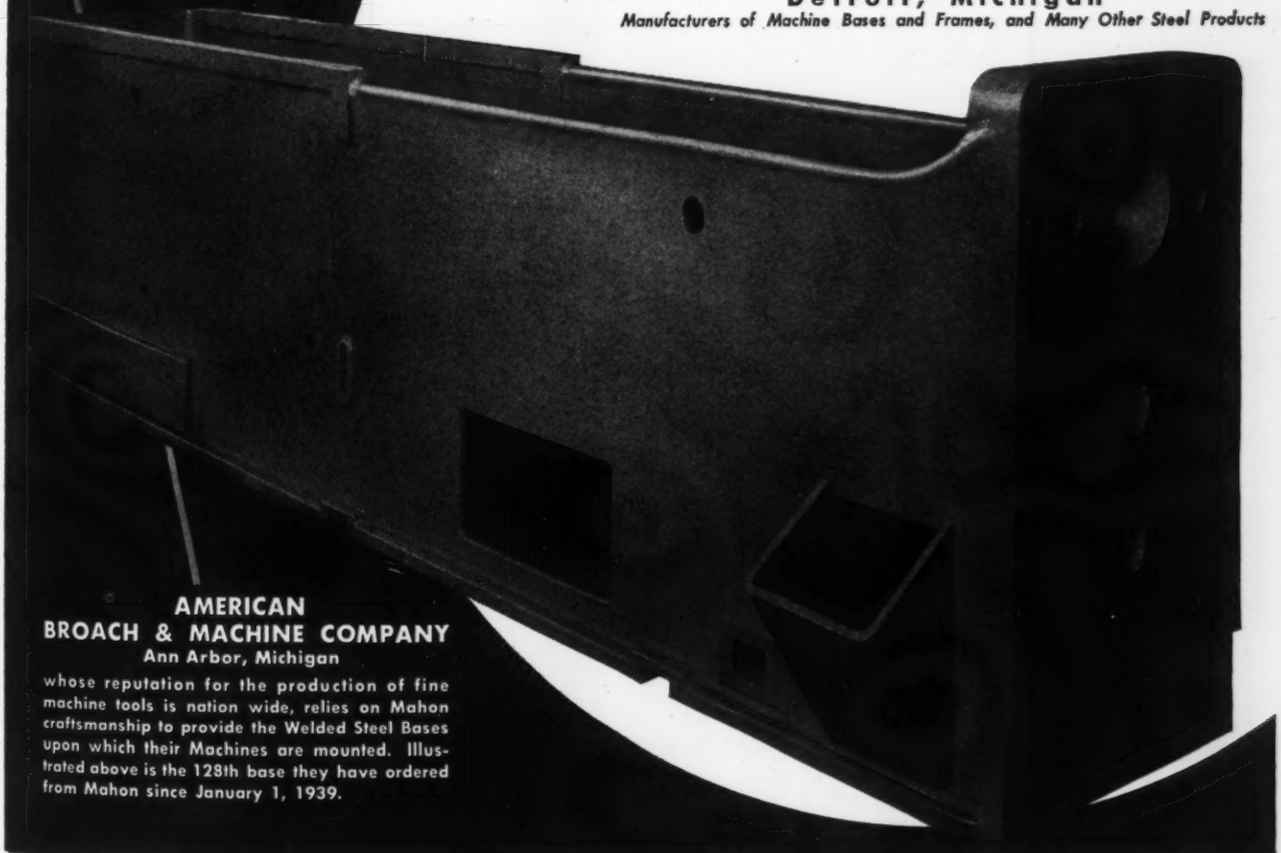
Welded STEEL Machine BASES

127 REPEAT ORDERS IN LESS THAN 3 YEARS FOR ONE COMPANY!

Satisfaction
Founded on Consistent Quality

It cannot be considered coincidence when the same manufacturer returns again and again to the same source of supply for his machine base requirements. Certainly, not to the extent of 127 repeat orders. That means consistent satisfaction founded on the consistent quality of Welded Steel Machine Bases, as fabricated by Mahon. If you, likewise, demand machine bases of exceptionally fine finished appearance and accuracy—bases upon which you will be proud to place YOUR product—send your blueprints to Mahon for quotations.

THE R. C. MAHON COMPANY
Detroit, Michigan
Manufacturers of Machine Bases and Frames, and Many Other Steel Products



AMERICAN BROACH & MACHINE COMPANY
Ann Arbor, Michigan

whose reputation for the production of fine machine tools is nation wide, relies on Mahon craftsmanship to provide the Welded Steel Bases upon which their Machines are mounted. Illustrated above is the 128th base they have ordered from Mahon since January 1, 1939.

MAHON

WATER SYSTEMS
AIR COMPRESSORS
REFRIGERATOR TRUCKS
These Are But a Few of the Wide Range of Applications of Briggs & Stratton Motors
BRIGGS & STRATTON
Dealers AND DISTRIBUTORS . . .
Who Know Value and Quality in Merchandise Prefer to Sell Equipment Powered by
BRIGGS & STRATTON
Dealers and distributors know that Briggs & Stratton air-cooled motors provide dependable, trouble-free power for all types of tools, appliances and equipment—such equipment is easier to sell and keep "sold." These motors assure complete "customer satisfaction" — and deliver full value and service for every dollar of cost.
BRIGGS & STRATTON CORP.
Milwaukee, Wisconsin, U. S. A.

function is performed hydraulically. A gear pump which supplies the necessary hydraulic pressure is attached to the driveshaft, which shaft also rotates the flyweights and the integral cylindrical housing in which they are mounted. Centrifugal displacement of the flyweights serves to raise or lower a valve sleeve. Ports in this sleeve, when properly positioned, permit fluid to flow either above or below a piston in a servomotor hydraulic cylinder which effects the movement of the engine throttle. Displacement of the servomotor piston is hydraulically co-ordinated with the throttling piston shown in the left center of the illustration. This throttling piston repositions the piston valve with respect to the new position of the valve sleeve, thus resetting the engine throttle to accommodate the load change.

Compen ates for Load Change

In operation, if the load decreases the engine speed will increase and cause the flyweights to be displaced outward. This movement raises the valve sleeve, permitting fluid from the pressure chamber to flow to the underside of the servomotor piston. As the piston is raised it retards the engine throttle and also displaces fluid from its upper side to raise, through an intermediate cylinder, the throttling piston. The throttling piston by means of the forked lever attached to its rod raises the piston valve which closes the passage between the pressure chamber and the under side of the servomotor piston. Thus the throttle is reset and the governor controls the engine speed under the new condition of load. The fact that the chamber containing the flyweights is filled with oil and the entire assembly rotates as a unit provides the damping action which obviates hunting due to cyclic impulses from the engine.

Pump Has Hydraulic Plunger

Design of pumps for handling sludge or other abrasive and corrosive fluids must take into consideration the possibility of damage resulting from the scoring of bearing surfaces, jamming of plungers or valves and the clogging of fluid passages. In a patent assigned to the Abercrombie Pump Co. these difficulties have been circumvented by a design which eliminates all metal-to-metal bearing surfaces in contact with the fluid being pumped. A baffle containing bleeder ports or orifices causes the pump passages to act as a by-pass for the piston in the event that either one or both of the valves become jammed.

Actually the piston of this pump never comes into contact with the fluid. Instead what might be termed the pump cylinder is enclosed by an elastic sleeve or envelope called the expansible member. This sleeve is filled with water or other convenient liquid. The piston is merely a rod stepped to two different diameters. In the illustration the piston has moved to the right for about two-thirds of its stroke. This movement displaces the liquid in the sleeve, causing the expansible member to distend

For all-around Conservation

LET'S LIGHTEN THE REPLACEMENT LOAD

Replacement of the planes, tanks, trucks, guns, ships, and machinery now in production will soon impose a tremendous added burden on the Nation's productive facilities. High among the many excellent materials able to lighten the replacement load by insuring long service to machinery parts for defense and civilian use, stands Nitralloy.

Nitralloy, an alloy steel, when treated by the Nitriding process after machining, produces the hardest steel surface known.

Naturally, Nitralloy, a major defense metal, is widely used in planes, tanks, trucks, ships, artillery—for parts that must resist wear, impact and fatigue. Not only are the products of our metal-working industry better fitted by Nitralloy to withstand failure, but the very machines and tools with which these products are made similarly have their useful life span lengthened.

Thus Nitralloy, by conserving the fruits of our labors, stretches our resources of steel, fuel, power, transportation, plant facilities and personnel.

Obviously the same properties that made Nitralloy a veritable life preserver for defense material, find wide application in the normal activities of industry.

For complete technical details and list of applications, write for the Nitralloy Data Book—and feel free to consult us regarding the best Nitralloy formula and treatment for any given purpose.

NITRIDING

is the process of case hardening certain alloy steels by means of a nitrogenous medium, such as ammonia gas. The alloy steels that are most suitable for Nitriding are known as

NITRALLOY

THE NITRALLOY CORPORATION

230 PARK AVENUE — **NEW YORK, N.Y.**

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CRUCIBLE STEEL CO. OF AMERICA ..... NEW YORK, N. Y.
FIRTH-STERLING STEEL CO. ..... McKEESPORT, PA.
REPUBLIC STEEL CORPORATION ..... CLEVELAND, O.
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TAYLOR FORGE

FORGED and ROLLED STEEL RINGS

Any size from 12" O. D. to 100" O. D.

IF your product is one that requires the use of forged or rolled steel rings—and particularly if special heat treating and testing are required to insure desired characteristics—then you will be interested in the rings produced by an organization that offers:

—skill and knowledge based on more than 40 years of experience in the forging and rolling of steels and alloys.

—finest forging, rolling and machining equipment.

—exceptional facilities for heat treating.

—most complete and modern laboratory testing equipment.

All these combine to make Taylor Forge a thoroughly dependable source of supply for all types of forged and rolled steel rings and to guarantee your getting *exactly* what you specify.

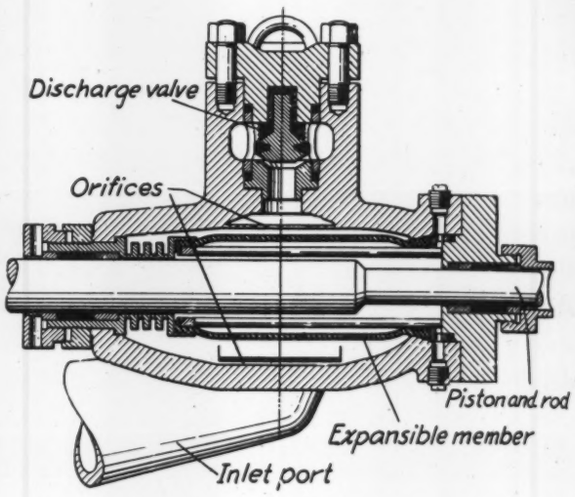
Inquiries are invited

TAYLOR FORGE & PIPE WORKS

General Offices & Works: Chicago, P. O. Box 485
New York Office: 50 Church St.
Philadelphia Office: Broad Street Station Bldg.

and thereby effect a pumping action.

One of the hazards of this type of construction is that the fluid in flowing through the pump will carry along with it the elastic member, forcing it into one of the valve ports. In this pump a baffle is provided which completely separates the elastic member from the main pump passages. Diametrically opposite orifices are provided in this baffle so that the flow through the upper orifice equals



No working parts of pump plunger assembly are in contact with the fluid being handled

the flow through the lower. Thus there is no tendency for the elastic sleeve to be swept along with the fluid being pumped.

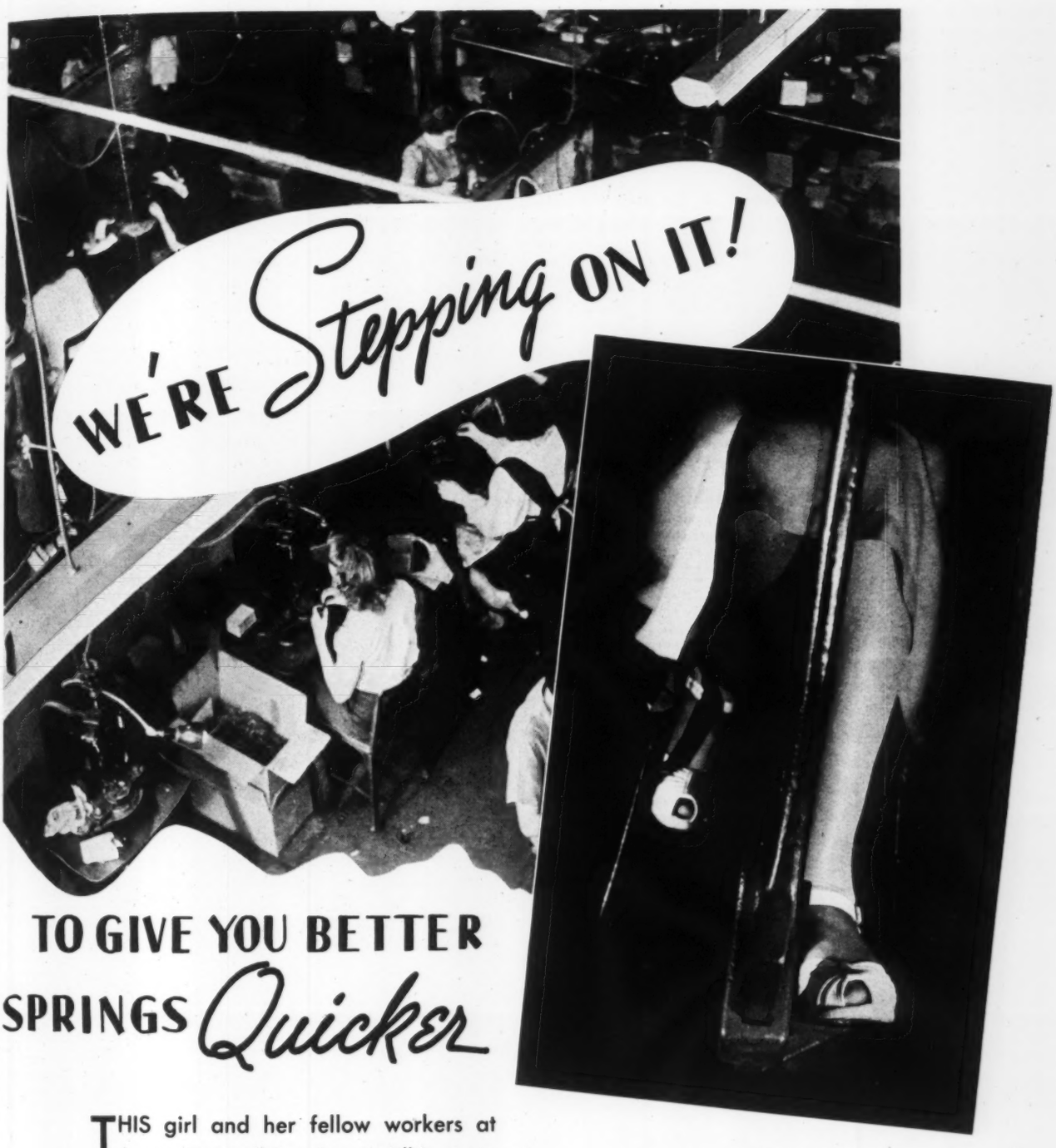
Both the inlet and outlet valves are identical and are of the poppet type. Metal-to-metal contact in the guide is eliminated by molding the valve stem into a block of soft rubber which is in turn molded into the pump housing. Similar molded rubber inserts in the valve disk prevent metal contact with the seat.

Synchronizes Dual Drive

WHEN it is necessary that a load be driven by two prime movers such as internal combustion engines, steam engines, etc., it is necessary that the speed of each be maintained the same in order that each should carry its proportional part of the load. It is desirable in synchronizing devices to achieve this end that they consume a minimum of power and that they do not constitute an integral part of the power transmission system. Utilization of a simple differential gear system meets these requirements, as disclosed in a patent issued to J. A. Kennedy.

Illustrated is the complete control mechanism. Each of the worm gears is driven by a mechanical connection from one of the two or more prime movers. Such a connection may be accomplished by means of a length of flexible cable driven by the camshaft or other convenient take-off shaft of the engine and need not be driven at full engine speed.

Each of the worms drives its respective worm-



TO GIVE YOU BETTER SPRINGS *Quicker*

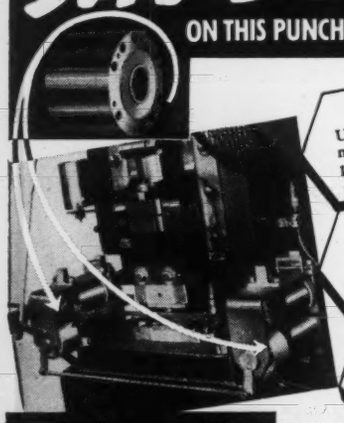
THIS girl and her fellow workers at Accurate are "stepping on it" in more ways than one—crowding their machines to produce springs and more springs. It's like that all through the Accurate plant—the only restraining influence on speed is our exacting inspection. We will not push production to a point where it is necessary to sacrifice accuracy and quality.

Here you can be sure of painstaking attention to every requirement of your order—design, materials and delivery! Yes, sir, our motto is: *"step on it"* to give you better springs, quicker. Let's talk it over.

Accurate Springs

ACCURATE SPRING MFG. CO., 3813 West Lake St., Chicago, Ill.

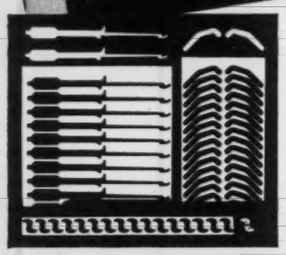
MORSE Indexing CLUTCHES
SAVE 8% IN STOCK
ON THIS PUNCH PRESS DOUBLE ROLL FEED



MORE PUNCHINGS
Uniform indexing control permits closer and more punchings per given stock—less scrappage greater savings!

ACCURATE INDEXING
Greater accuracy permits a higher rate of feed resulting in considerable increased machine production.

25 DIFFERENT PUNCHINGS
Varying speeds and index strokes to accommodate various stocks is accomplished by one machine adjustment.

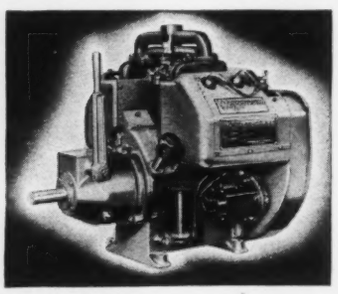


SUPERIOR RATCHETING METHOD
Morse Indexing Clutches affected an 8% stock saving on above installation. Because of greater indexing accuracy, closer and more uniform punchings were possible, as shown at left. Rate of feed was increased considerably There is a Morse Clutch to meet your requirements—investigate *now.*

IMPORTANT—Send for engineering data. It contains helpful ratcheting and indexing information!

MORSE INDEXING AND FREE-WHEELING CLUTCHES
Morse Chain Co., Detroit, Mich. • Ithaca, N. Y. • Div. Borg-Warner Corp.

Model VE-4
4 cycle 4 cylinder V-type, heavy-duty, air-cooled engine . . . delivers 22 hp. at 2600 R.P.M.



Draft Horses!

It figures out this way: 22 hp. packed into a 285-lb. heavy-duty engine, or 13 lbs. of compact engine weight for each husky horsepower. That's the sensational Wisconsin VE-4!

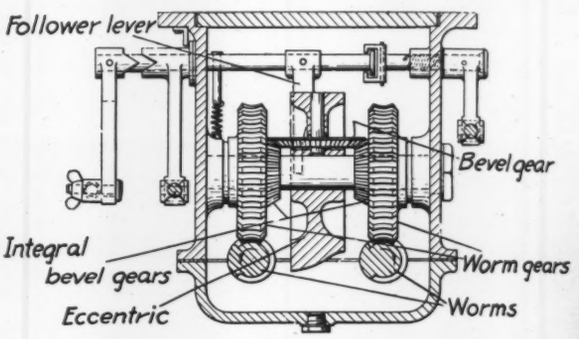
Harness this eager, dependable power to *your* kind of equipment and the kind of work you want it to do . . . the way it should be done. Detailed data on request. Write: Dept. L-12

MOST POWER PER POUND
HEAVY-DUTY AIR-COOLED ENGINES

by WISCONSIN MOTOR CORPORATION
Milwaukee, Wisconsin, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

wheel which is in turn mounted freely on a transverse shaft. Integral with the base of each of these wormwheels is one of the bevel gears of the differential system. The third of the differential bevel gears is mounted on a shaft fastened in the eccentric or drum cam. This eccentric is keyed or pinned to the same shaft as that on which the wormwheels are bushed. The eccentric cam has two peripheral blended surfaces, one eccentric with its shaft and



Eccentric portion of drum cam adjusts speed of follower engine to that of leading engine

the other concentric with it. A follower lever actuated by the eccentric is pinned to the upper shaft, rotation of which controls the speed of one of the engines with relation to the other. Shifting the follower lever to the concentric or right-hand portion of the eccentric throws the control mechanism out of operation and the engines may be run independently.

When synchronization is desired the follower lever is shifted to the left. If both engines are turning at the same rate of speed each integral bevel gear drives the central bevel gear at the same rate of speed and hence no rotation of the eccentric is experienced. However, if one engine speeds up, the central bevel gear and the integral eccentric rotate about the axis of the wormwheel. This causes a displacement of the follower lever which effects synchronization of the follower engine.

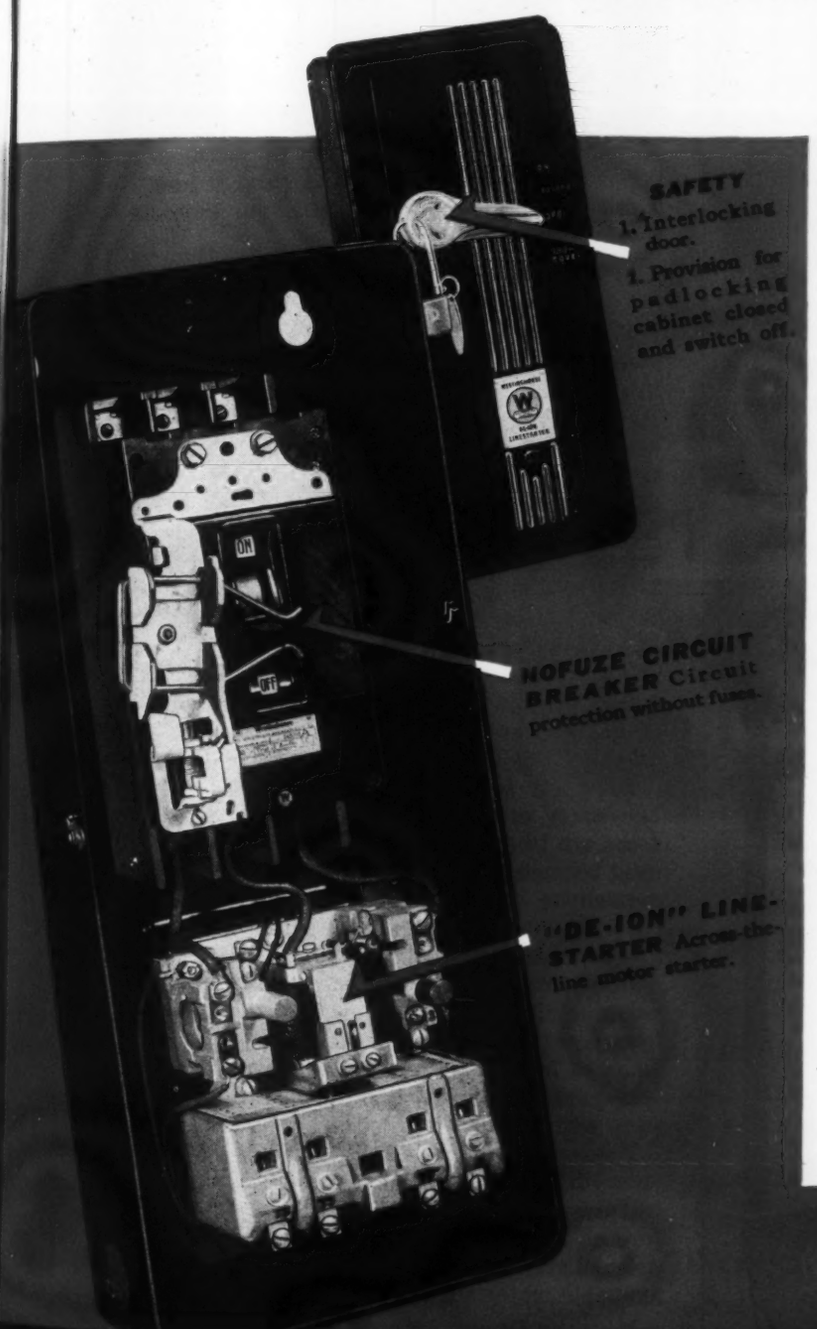
Metals at Low Temperatures

Representing the result of two years study by a joint A.S.M.E.-A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals a report has been published and is available for $2.50 from A.S.T.M. Headquarters, Philadelphia. A subcommittee headed by Francis B. Foley assembled the data from a large number of laboratories and referred it to Dr. Gillett at the Battelle Memorial Institute for classification.

Following a discussion of impact resistance, which covers limitations, effect of testing variables, impact velocity and cooling technique, there is a section devoted to impact data for nonferrous materials. The most extensive portion of the publication covers a wide range of ferrous materials including a tabulation of low temperature properties.

save INSTALLATION TIME INSTALLATION SPACE

WESTINGHOUSE COMBINATION LINESTARTER


SAFETY
1. Interlocking door.
1. Provision for padlocking cabinet closed and switch off.
NOFUZE CIRCUIT BREAKER Circuit protection without fuses.
"DE-ION" LINE-STARTER Across-the-line motor starter.

GIVES YOU ALL FOUR IN ONE UNIT

- MAGNETIC MOTOR STARTER
- MANUAL MOTOR-CIRCUIT SWITCH
- MOTOR OVERLOAD PROTECTION
- NOFUZE CIRCUIT PROTECTION

Here's everything you need for the motor circuit in one compact, easily installed unit. You save wiring, installation time, space.

Available in dust-tight, watertight or explosion-resisting enclosure. Push button built-in or mounted separately.

NOFUZE CIRCUIT BREAKER

Eliminates conventional fuse equipment. Acts as manual disconnect switch in "Off" position. Bi-metal gives positive protection against short circuits and severe overloads.

"De-ion" principle quenches arcs instantly and saves contacts. Impossible to hold closed on short circuit. Positive indication of circuit condition. Nothing to renew or replace when restoring service.

"DE-ION" LINESTARTER

Starts, stops and protects the motor. Provides across-the-line magnetic starting. Gives full protection against overload and under-voltage.

Operation by push button, float or pressure switch. "De-ion" quenchers protect contacts. Bi-metal gives accurate, unvarying overload protection. Vertical magnet operation speeds contact opening and prevents accidental operation.

WESTINGHOUSE ELECTRIC & MFG. CO.
EAST PITTSBURGH, PA.

J-21144

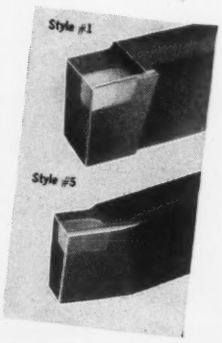
Westinghouse
MOTORS AND CONTROL

SAE 4340

AN EXAMPLE OF HIGH STRENGTH STEEL Economically Machined with KENNAMETAL

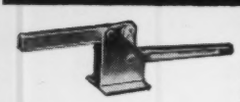
Chrome-nickel-molybdenum steel (SAE 4340) heat treated to 387 Brinell can be turned at 150 to 250 ft. per min. *without previous annealing* by using KENNAMETAL-tipped carbide tools. Airplane retractor tubes made from SAE 4340 are being turned and bored five times faster with KENNAMETAL tools than with high speed steel tools, producing a smooth, accurate surface free from tears which might start fatigue cracks.

If high machining costs have limited your choice of steels for machine parts—investigate KENNAMETAL, the accepted carbide tool material for turning, boring, and facing steel of all hardnesses up to 550 Brinell. Tell us your problem—we will gladly advise you without cost or obligation.



McKENNA METALS Co.
146 LLOYD AVENUE, LATROBE, PENNA.
FOREIGN REPRESENTATIVES: U.S. STEEL EXPORT CO.
Exclusive of Canada, Great Britain and Possessions

PECO Time-Saving CLAMPS . . . for JIGS and FIXTURES



No. 1561 Horizontal Quick-Action Clamp

No. 1512 Toggle Clamp

No. 1513 Toggle Clamp (Extended Base)

Specify PECO Quick-Acting Clamps, they're *Engineered* for production-speed and operating ease—are faster, hold tighter, last longer.

Adaptable to jigs and fixtures for every conceivable application PECO Clamps are far less costly than individually designed equipment. Available in sizes to meet your requirements. Note the PECO Horizontal Quick-Action Clamp with handle *down* out-of-the-way. You can get to the work easier.

PECO Clamps are *Engineered* by Production Men for today's production methods.

PECO Clamps are the only clamps with drop forged handles and clamping bars.

Send for this file size catalog of PECO production tools. Write Dept. D12

No. 1514 Quick Action Toggle Clamp

PRODUCTS ENGINEERING COMPANY
700 E. FLORENCE AVENUE, LOS ANGELES, CALIFORNIA

Plastic Plywood Comes of Age

(*Concluded from Page* 55)

ever, the species lose their identity as the bonding pressure is increased. The wood structure becomes denser with higher pressures, giving a direct relation between the specific gravity and the compressive, tensile and shear strengths.

Rotary-cut sheets are used almost wholly. This provides economical use of lumber logs and gives bigger sheets than could be sawed. For convenience in producing plywood and for effecting the strongest bonds, phenolic dry sheets placed between the wood sheets give best results. For the most part, powders, solutions and suspensions yield bonds of lower strengths. Thus if strength can be sacrificed liquid bonds may be used to advantage and at lower cost. The resin may be thinned with flour to economize further when possible.

Is Readily Formed

Forming is accomplished by curing in a mold or wetting the surface of plywood sheets and shaping in a heated mold. Pressure is often built-up through the utilization of a flexible bag in which a hot liquid is circulated. This forces the plywood to take the shape of the die, thus cheaply and effectively fabricating the desired shape. This method, however, is limited as to both the amount of heat and pressure. Forming should be performed at an angle to the grain to minimize possible rupture.

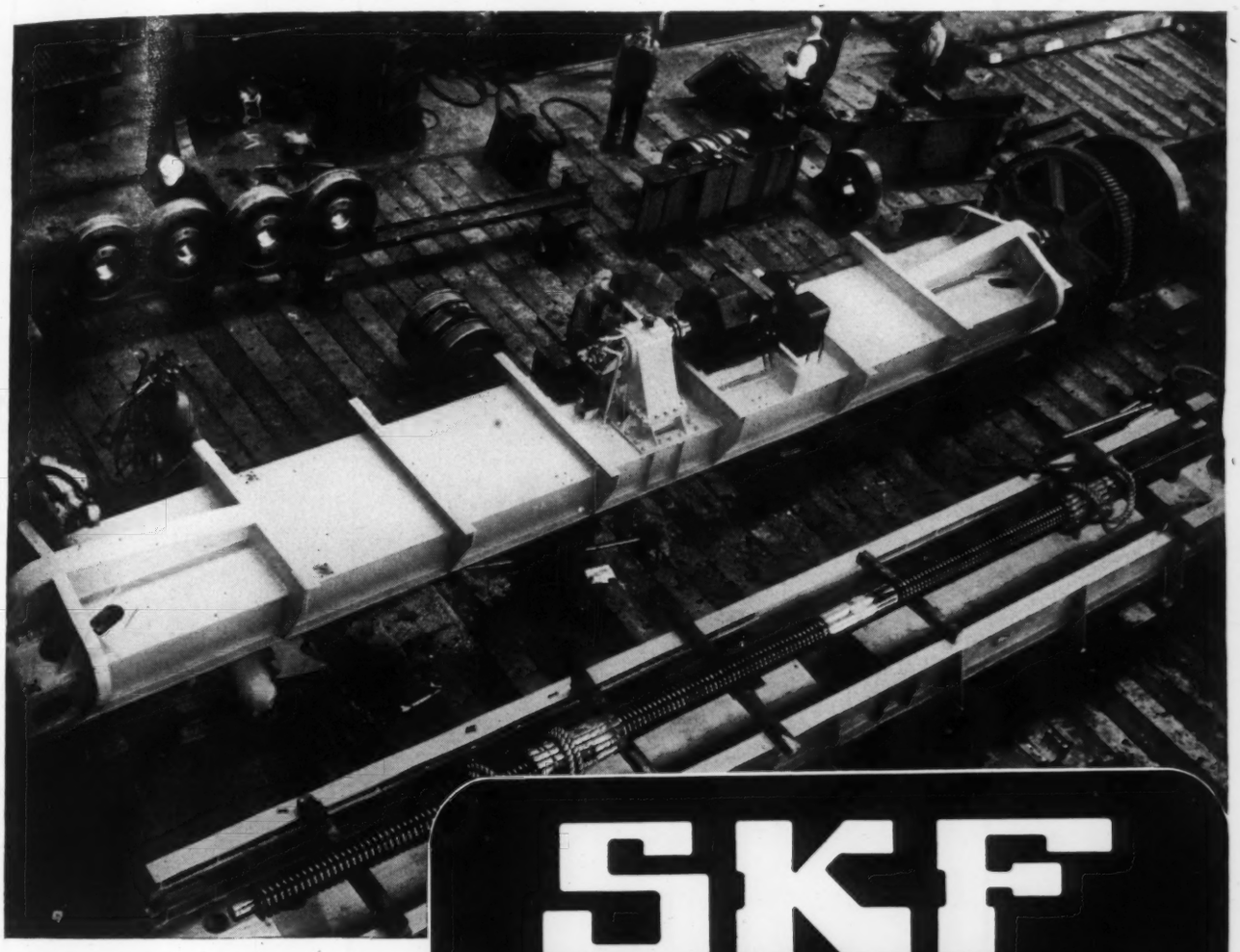
Butt joining is now accomplished without the use of tape. Thin plywood, especially, can be joined stronger than the wood itself, according to tests conducted by T. D. Perry. Machines apply the resin, heat and cure the joint on passing between rollers. The finished joint is barely visible.

Assembly joints using adhesives are superior to fastenings, especially on aircraft where smooth surfaces are important. For joining, phenolics are not used because of their low heat reaction. Urea formaldehyde with a catalyst, live for four hours, cures at room temperatures. Properties, however, are improved by curing at 130 to 140 degrees Fahr.

Bonds may be improved in the near future by developing the high-frequency induction process for heat generation. This method has possibilities because of its ability to cure thick sections uniformly and quickly with less loss of moisture than is possible with present methods.

Possessing dimensional stability, distributed strength, availability, ease of fabricating, economical use of materials, plastic plywood comes to the fore as an important development at a time when defense production requires maximum utilization of available materials.

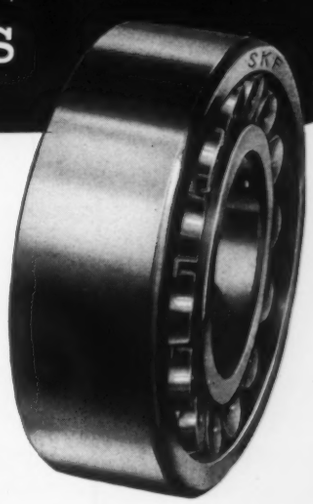
MACHINE DESIGN appreciates the helpful co-operation of the following companies in the preparation of this article: Douglas Fir Plywood Assn. (*Figs.* 2, 5); Harbor Plywood Corp.; Langley Aviation Corp. (*Fig.* 1); M & M Woodworking Co.; Resinous Products and Chemical Co. (*Fig.* 6); and Technical Plywoods.



● *This Screw Luffing Mechanism for a 20-ton Full Revolving Shipyard Crane, in process of assembly at DRAVO CORPORATION'S Neville Island Plant, is SKF-equipped in sheaves and luffing screw drives.*

SKF

BALL AND ROLLER BEARINGS



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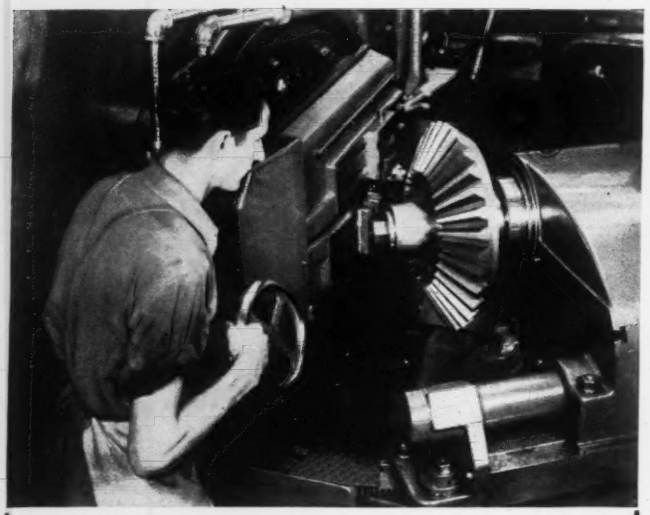

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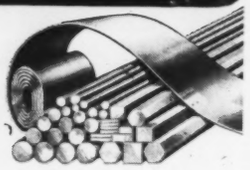

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Theory of Elasticity in Practical Design

(*Continued from Page* 63)

ation becomes more and more extensive, society can less and less afford the waste of its store of materials. To those of us in the engineering profession she now lays a challenge—conserve!

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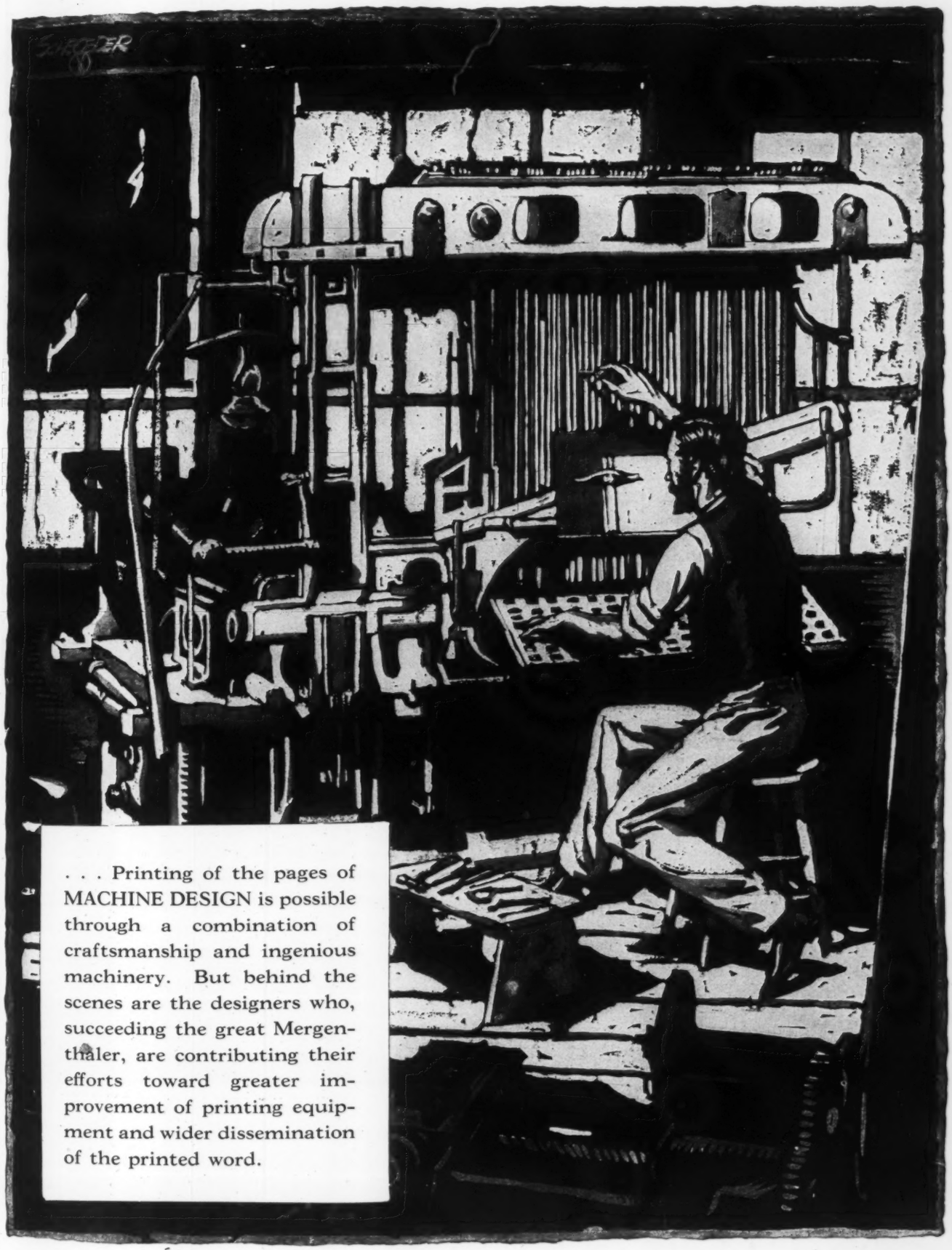
Nomenclature for Series*

A	Cross section area
E	Young's modulus of elasticity
E_1, E_2	Elastic moduli for rollers r_1 and r_2, respectively
F	Body force per unit of volume
G	Shear modulus of elasticity
H	Calibration value of photoelastic model material (lb./in/fringe)
I	Moment of inertia of cross section
M	Resultant external bending moment on a section (positive when the summation to the left of the section is clockwise)
M_x	External moment at the section x
M_s	Statical moment of area of cross section from y to c
N	Elastic factor in contact loading, $(1-\lambda_1^2)/E_1+(1-\lambda_2^2)/E_2$
P	Total applied load, usually concentrated
Q	The principal stress difference (S_1-S_2)
S	The equivalent failure stress
S_1	A principal stress, usually the largest

(*Concluded on Page* 136)



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Kilgore
Louisville
Memphis
Nashville
New Orleans
Philadelphia
Pittsburgh
Richmond
San Francisco
St. Louis
Tulsa

S_2	The second principal stress
S_3	The principal stress in the "third" direction
S_x, S_y, S_z	Normal components of stress in the X, Y or Z direction, respectively
S_ρ, S_θ	Normal components of stress in the radial and tangential directions, respectively
V	Resultant external shear on a section (positive when the summation to the left of the section is up)
V_x	External shear at the section x
W	Total applied distributed load
	Total energy
a	Half of width over which contact load is distributed
b	Thickness, in direction perpendicular to the plane of stress
c	Distance from the centerline of section to the outer surface
d	Depth of beam
e	Shear "detrusion", also eccentricity
g	Diameter of stress circle in semi-infinite plate loading
k	Radius ratio, r_1/r_2
n	Fringe order
q	Intensity of a continuously distributed load applied normally to the boundary
q_o	Intensity of contact loading at the center
r	Radius
r_1, r_2	Inside and outside radius, respectively
	Radii of rollers in contact loading
r_o	Centerline radius, $(r_1+r_2)/2$
t	Thickness of cylinder wall, etc.
u	Radial interference in force fits
u_ρ, u_θ	Radial and tangential components of strain, respectively
u_x, u_y, u_z	Components of strain in the X, Y or Z directions, respectively
v	Intensity of a continously distributed load applied parallel to the boundary
v_m	Maximum shear stress obtaining in any direction at a given point
v_{xy}, v_{yx}	Shearing components of stress, on the plane on which S_x or S_y are acting, respectively
$v_{\rho\theta}, v_{\theta\rho}$	Shearing components of stress in polar co-ordinates
w	Width
	Energy per unit volume
α	Inclination of load on end of wedge, see Fig. 75
	Inclination of the principal directions measured from the X axis to the direction of S_1
ε	As used in uniform load on semi-infinite plate, see Fig. 57
	Wedge angle, see Fig. 75
	As used in concentrated loads on rollers, see Fig. 72
	Relative roller curvature between contacting rollers, $\frac{1}{2}(1/r_1+1/r_2)$
$\gamma_{xy}, \gamma_{xz}, \gamma_{yz}$	Unit shear strain in the XY, XZ or YZ planes, respectively, and parallel to the coordinate axes
ϵ	In force fits, inches interference per inch of diameter
$\epsilon_x, \epsilon_y, \epsilon_z$	Unit direct strain in the X, Y or Z direction, respectively
$\epsilon_\rho, \epsilon_\theta$	Unit radial and unit tangential strain
θ	Angle in polar co-ordinates
λ	Poisson's ratio, known also as the "factor of lateral contraction"
λ_1, λ_2	Poisson's ratio for rollers r_1, and r_2
ρ	Radius vector in polar co-ordinates
$\phi = \phi(x, y)$	The stress function. A parameter between the stress differential relations and the condition of compatibility of Equation 28
ω	Angular rotation in radians per second

*Duplication of symbols is used only where no possible confusion can arise, thus permitting utilization of conventional symbols.

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9	19.7	24.9
10	24.9	31.3
	31.4	
11		39.4
12	39.5	49.6
13	50.0	62.5
	62.9	
14		78.8
15	79.4	98.9
16	99.0	124
	125	
17		156
18	158	197
19	199	247
	256	
20		310
21	315	389
22	398	487
	503	
23		611
24	633	763
25	794	955
	1000	
26		1190
27	1260	1490
28	1580	1850
	2000	
29		2290
30	2520	2850
31	3160	3510
	3990	
32		4360
33	5050	5300
34	6330	6420
	7940	
35		7900
36	10050	9410
37	12650	11600
	15900	
38	20100	14300
39	25200	16700
40	31700	19100

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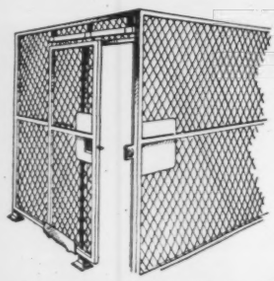

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Deep Drawing Answers Production Problems

(*Continued from Page* 68)

drawn metal it was found not to be commercially practicable to hold this dimension. Instead a 1/16-inch radius was used.

A relative idea of the cost of this part can be derived from consideration of the list of operations involved. The section shown at the left of *Fig.* 9 is blanked and drawn in the first operation. This draw is followed by an anneal to restore the plastic range. The part is then redrawn to its final shape. Next the edges are trimmed square and the small screw clearance holes are pierced. The longitudinal slots are then pierced one at a time on an indexing mandrel by a single punch.

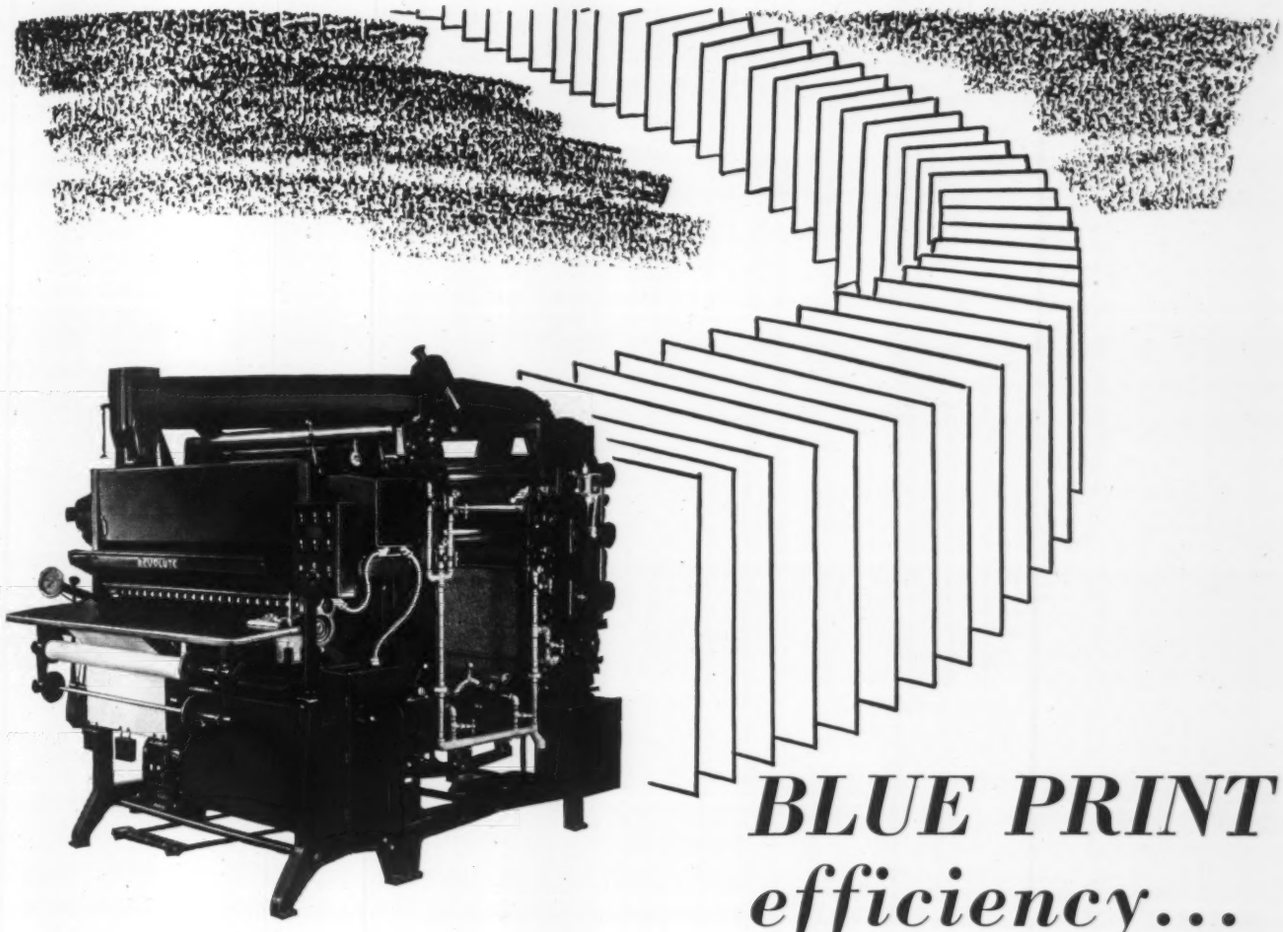
In addition to the complications involved in forming, the part illustrated in *Fig.* 10 is of interest because of the manner in which the contour is specified. In several respects such a method of contour specification is preferable to that of blended radii, since, in the latter case, the location of the center from which the radius is swung often presents a difficult problem to the die maker. From the previous molding clay analogy it will be evident from an examination of this part that the major difficulty in the drawing operation occurs at the knee of the bend. In fact, with the exception of the changing contours at each end, the metal in the substantially straight section on both sides of the knee is formed chiefly by bending, there being little movement of metal.

Increase Wrinkling Tendency

In the drawing operation, the comparatively deep flanges at the knee, combined with the fact that the problem of holding the blank is a difficult one, introduces a marked tendency toward tearing and wrinkling at this point. It is in parts such as this that spring-back is likely to cause the most trouble and, because of the varying section, it is only by a procedure of "cut and try" backed by extensive experience of the stamping manufacturer that the completed part conforms to the specifications of shape and contour.

After partial development of the blank it is bent to the contour specified for the upper edge and then drawn into the channel section. The 3/32-inch radius on the left pad of the part cannot be formed in the drawing operation. This radius is restruck in the trimming operation on this end. The end holes are then pierced in two separate operations, one for each end. The right-hand sectional view specifies that the channel section must be polished. In consequence the care necessary to eliminate scratches on this surface demands the utmost care in the preparation of the tools and in the selection of materials for them.

In connection with the assembly of stamped parts by spot welding, the end flanges demonstrate an inexpensive expedient which facilitates this



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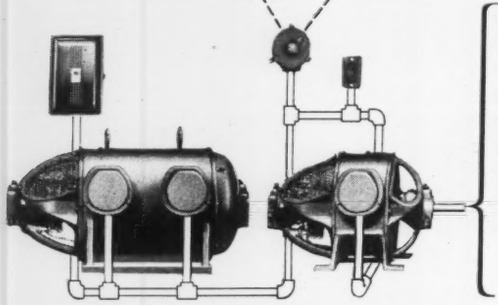

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welding operation. In trimming, small pips or pimples are formed in these flanges. When the piece to which the part is to be assembled by welding is pressed against these pips extremely intimate contact is attained. This greatly improves the weld efficiency and practically eliminates the risk of warpage by overheating. Also the several welds can be made in a single welding operation. Electrodes are used which cover the entire flange but, since the two flanges to be welded together are in contact only at the pips, it is there and there alone that the welds are formed.

Restruck to Finish Form

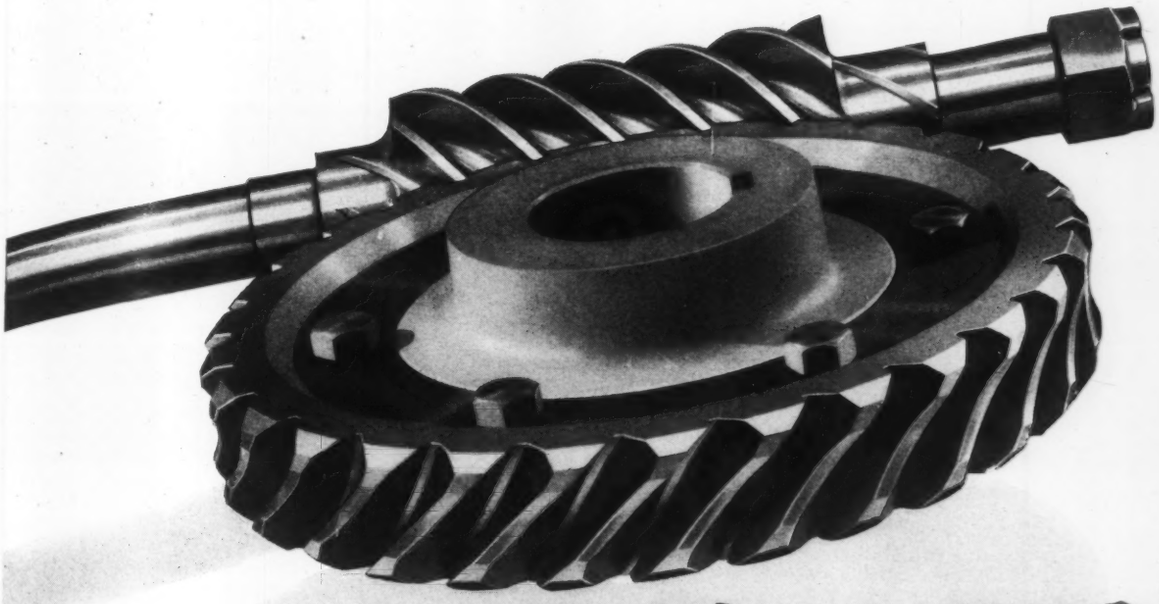
A subassembly which, with the exception of two nuts, is made entirely of stamped parts welded together is shown in *Fig.* 11. This part is a machine standard consisting of three legs, each of which carries a caster. The leg extensions are made from strip stock, sheared to length and drawn. Because of the change in section illustrated by the two views at the right as well as the pointed shape of the channel combined with its considerable depth, holding beads are essential in the die to prevent wrinkling. After the drawing operation the edges of the channel are trimmed. The part is then restruck to iron out irregularities in the surface as well as to give the shape its finished form. This is particularly necessary because the right end of the channel must be a close fit with the three legged standard to which it is to be welded.

The hub or standard is an unusually complicated deep-drawn part. Hence a high grade, deep drawing, low carbon steel is required. Because of its complications an accurate blank cannot be developed. Therefore, after the drawing operation, it is essential that the part be trimmed all around. In forming the hub three separate draws are required in addition to the trim. To finish, a restriking operation is performed which produces the final specified shape.

Special Dies Reduce Cost

The flange tube or post support is welded to the mounting plate in the bottom of the hub and this plate is in turn welded to the lower edge of the hub shell. The flange on the tube is formed in two operations. First a taper punch is used to expand the ends to about a 30-degree angle. A flattening punch is then used to complete the flange for welding. In parts of this kind where considerable difficulty might be anticipated in removing the finished tube from the die after the flanging operation a hinge-type die is used to support the flange. This may be opened after the forming operation and the part easily removed.

Made from strip stock, the caster bracket is cut off and perforated in one operation. The retainer or cage for the nut is then formed in another operation and welded to the bracket with the nut in place. In assembly, the components are spot welded together and the legs are then gas welded



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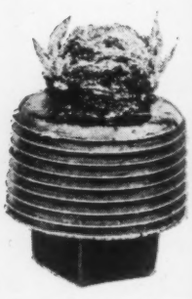

Unretouched photo shows metal removed from gear case after 24 hours' operation.

LISLE CORPORATION
Box 1003, Clarinda, Iowa

Magnetic DRAIN PLUGS

to the hubs for the entire length of the joint.

In comparison with many stamped machine parts this assembly is not a high production part, yet the careful consideration in the design given to the utilization of the advantages of the press-working processes results in a part which for appearance, surface finish, strength and lightness can be matched by no other method of manufacture.

Fig. 12 is interesting chiefly because it represents what can be accomplished by a combination of bending, drawing, forming, slitting, ironing and piercing operations. Contour and tolerance specifications are critical and yet these in themselves do not add appreciably to the cost of the part.

Holding Problem Severe

Dimensional tolerance limitations as well as the limitations on the angles noted in degrees give evidence of the intimate familiarity of the designer with problems arising out of press-working processes. Such rigid specifications in addition to those in the appended notes should ordinarily be developed in consultation with the stamping producer. They are valuable not only because they indicate the acceptable limits on dimension contour and finish but because, by inference, they permit the stamping manufacturer a wide range of latitude at the noncritical points of the design.

Whenever, as in this case, a drawing operation is performed on one end of a part the problem of adequate holding in the dies is severe. Whereas the right end of the piece would ordinarily present little difficulty, the fact that the left end of the enlarged drawn section is integral with the essentially undrawn straight channel section, severe stress conditions are imposed at the point of juncture of these two parts. This condition is aggravated by the depth of the channel and extreme care must be exercised as it was in the part in *Fig.* 10 to prevent wrinkling and overstressing.

Saves Vital Time

It has been the purpose, in the several case histories discussed, to emphasize the possibilities and limitations of the press-working processes. A more thorough understanding of the stampings manufacturer's problems will inevitably be conducive to the saving of time in the design development stages of a part, will expedite the stampings manufacturer's work in developing his operation sequence and tools, and will result in appreciable economies in the finished parts.

In the third and last article of this series to be published in the January issue, the metallurgical aspects of deep drawing operations will be considered in the light of their influence on the selection and specification of metal for drawn parts.

MACHINE DESIGN acknowledges the valuable cooperation of the following companies in the preparation of this article: Geometric Stampings Co., Globe Machine & Stampings Co., and the Goat Metal Stampings Co., Inc.

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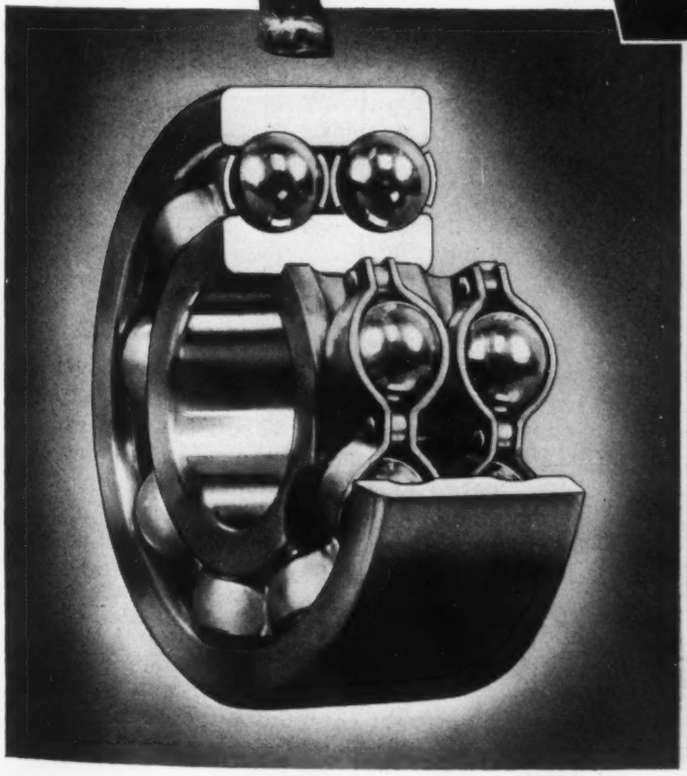

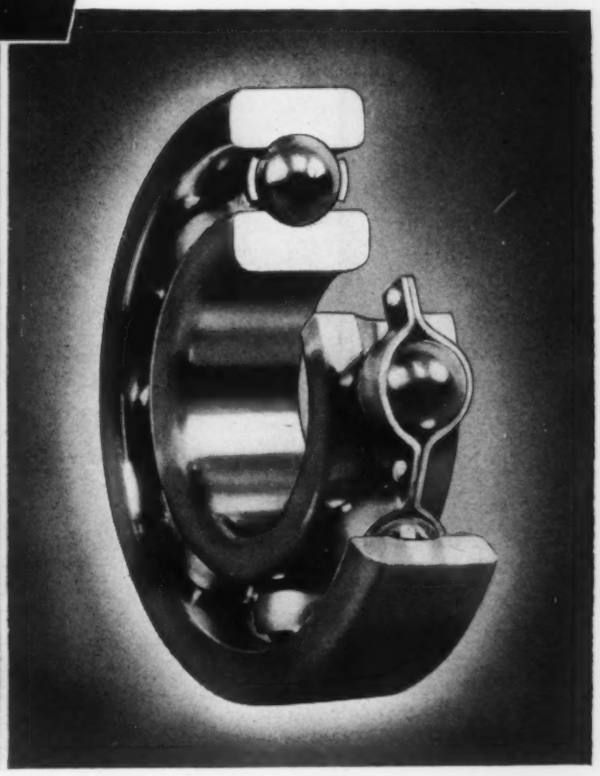

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GAST
ROTARY AIR
PUMPS

Utilizing Porcelain Enamel

(*Continued from Page 79*)

CHOICE OF ENAMEL: Enamels for cast iron range from soft, low-melting compositions with relatively poor resistance to abrasion and chemical action, to very hard grades resistant to all acids with the exception of hydrofluoric. The possible color selections are essentially the same as for sheet iron enamels. The softer enamels, usually containing relatively large amounts of lead oxide as a flux, formerly were used for sanitary parts and other applications calling for optimum appearance but mild chemical resistance. Accidental spilling of mineral acids on sanitary ware lead to the development of highly acid-resistant leadless enamels which are now in common use.

Proper Balance Is Essential

In the choice of enamel for a given purpose, a proper balance should be sought between resistance to abrasion and chemical attack on the one hand and additional manufacturing complications characteristic of the harder, more resistant enamels on the other, as illustrated by *Figs.* 2, 3 and 4.

PROCESSING OF ENAMEL: Two methods are employed for the application of enamel to sandblasted castings. In the dry process, used chiefly for sanitary ware, the casting receives a wet grip coat by spraying, dipping or slushing. After drying of this coat, the casting is heated in the enameling furnace to a fair red heat, removed to a "turntable", and as it is rotated and tipped to the necessary positions dry powdered enamel is applied with a vibrating screen. This operation is termed "dredging". When the piece has cooled to the point that no more enamel will adhere through incipient fusion, the casting is returned to the furnace. There the enamel fuses as the casting approaches furnace temperature. A second coat is applied in like manner and melted to the final glossy finish. In the wet process, enamel is applied by spraying or occasionally—as with sheet metal parts—by dipping.

Design Determines Process

Obviously the designer should know which of the two processes is to be used. If the dry process is involved, all portions of the piece should be so located that, by means of the turntable, they can be brought to an approximately horizontal position so that the dry powdered enamel may be applied by gravity. Pieces to be coated by the wet process should be designed on the same basis as sheet metal parts so far as receiving the sprayed enamel is concerned.

If the dry process is used, pieces are supported in the furnace by appropriate "bucks." Enamel cannot be brought to a proper finish where contact is made with the bucks, turntable or the forks

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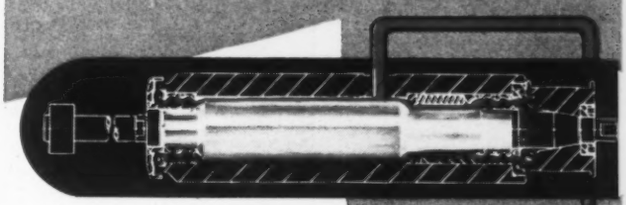

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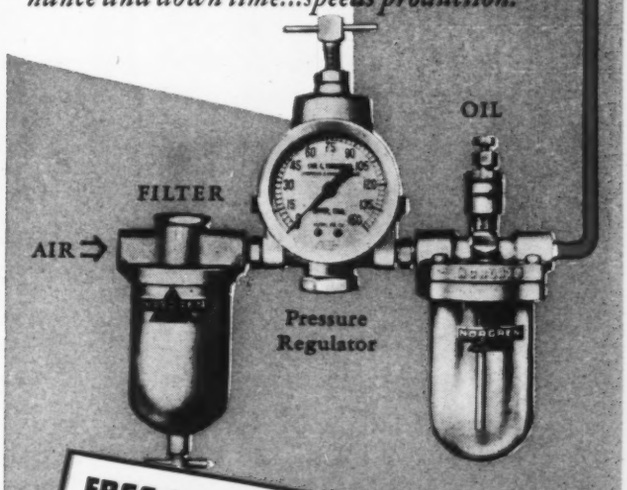

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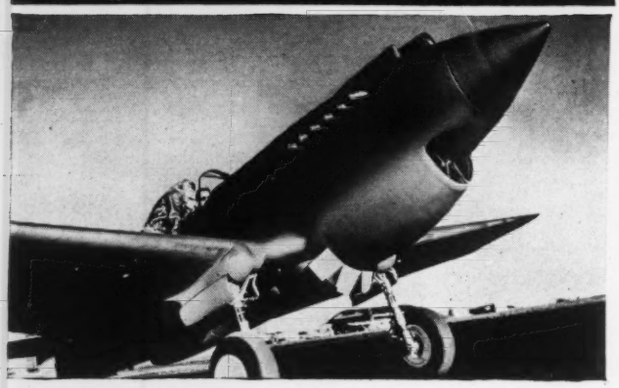

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with which a casting is transferred from one to the other. The wet process moreover involves resting the parts on suitable racks or hanging them from a conveyor, depending on the type of furnace or box. Points of contact with the supporting device cannot be enameled.

Furnace temperature for cast iron enameling is lower than for sheet metal and the heating cycle is longer. This allows for more even heating of the metal which, at best, usually involves greater differences in thickness than with sheet metal. It also permits the proper maturing of the enamel at temperatures low enough to prevent serious warpage of the castings.

Cast Iron Coating; Thicker

In general, enamel coatings on cast iron are thicker than on sheet metal; with dry process enamel they are several times thicker than wet process. Limitations due to deflection of metal are largely removed because of the rigidity of the casting. Incidentally, in designing parts that are to be assembled as in *Figs.* 3, 5 and 6, allowances for enamel must take into account the greater thickness of the finished coating. If the correct enamel has been applied properly to a casting of good design, the appearance and durability of the coating should be as satisfactory as for sheet metal enamel.

ASSEMBLING OF PARTS: The same general principles apply in the assembling of cast iron as with sheet metal parts. There is less danger of enamel failure through strains due to greater rigidity. However, holes that do not register should not be forced into position. To a limited extent, excess enamel can be removed from holes and edges but proper processing should make this unnecessary. Tabs and brackets cannot be deflected to compensate for warpage, but holes in them can be reamed within reasonable limits without endangering the enamel. It is better practice to design and process the piece so that such extreme measures will not be required.

Design Data Needs Standardizing

As mentioned previously, many of the basic principles developed in connection with the design of sheet parts also apply to cast iron and have not been repeated in this article. Also, the design of cast iron parts has not been as thoroughly standardized, or at least the best practices have not been reduced to a comprehensive record representing a cross section of the industry as a whole. With the general principles of vitreous enameling as a background, however, the facts that have been presented should enable the designer to arrive at satisfactory constructions that will result in enameled castings of proper appearance and quality.

Co-operation of the Bauch Porcelain Products Co., Chicago Hardware Foundry Co., Chicago Porcelain Enameling Co., Chicago Vitreous Enameling Co., Ferro Enamel Corp., Ohio Foundry Co., as well as their courtesy in supplying illustrations for this series of articles is greatly appreciated.

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This 16-speed Model "M" Monarch Lathe is designed to machine parts ranging from 14" to 120" length. The headstock and tailstock are equipped with duplicate "LOGAN" Air Equipment simultaneously tooled to face both flanges air valve, single constant production. "LOGAN" Expanding Mandrels, with interchangeable jaws to handle the entire range of sizes, support the work. Model R Revolving Type "LOGAN" Air Cylinders operate Mandrels. This heavy duty Air Equipment assures positive gripping rigid support of work. "LOGAN" engineers will be glad to make recommendations on your problems.

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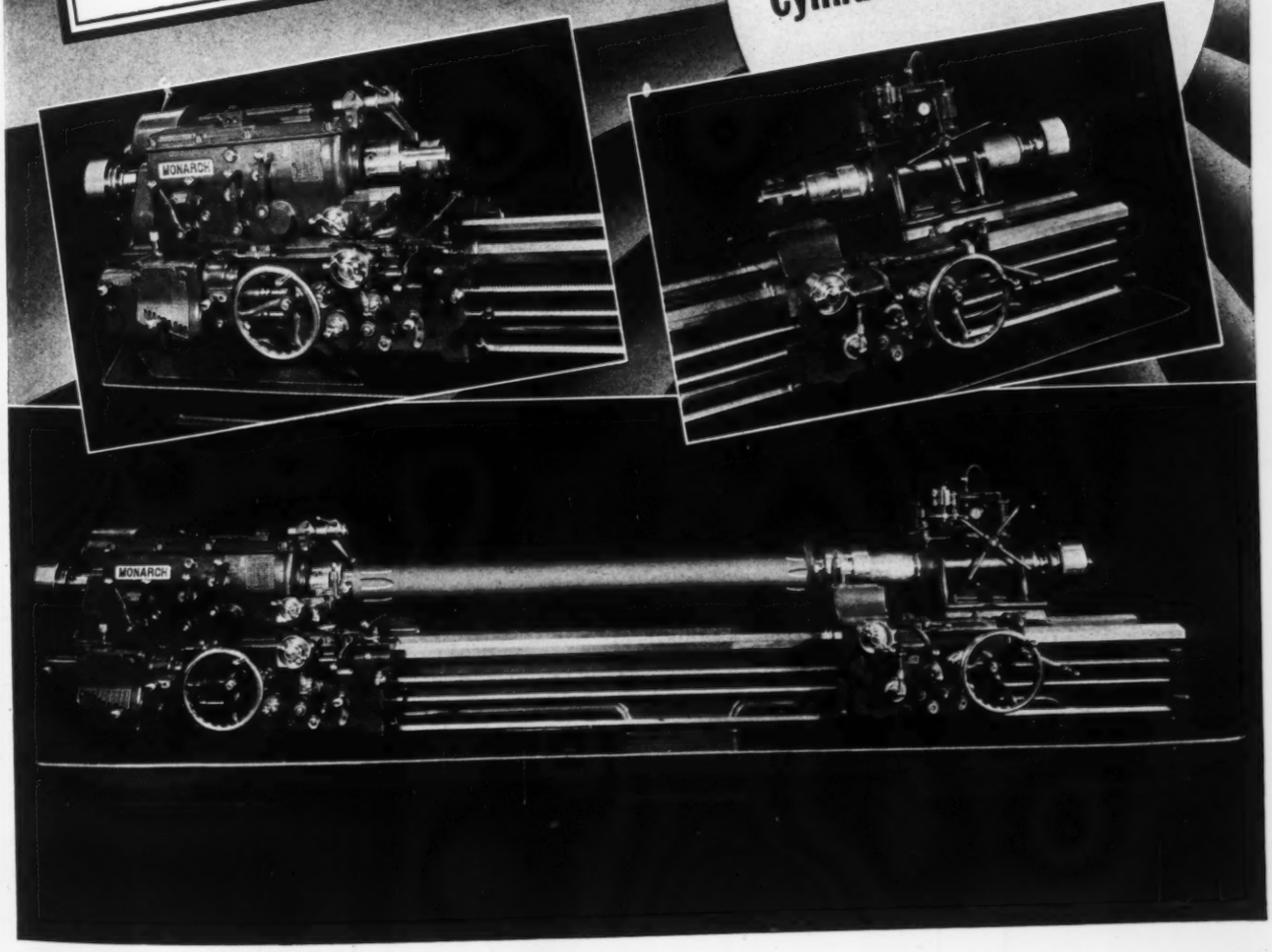
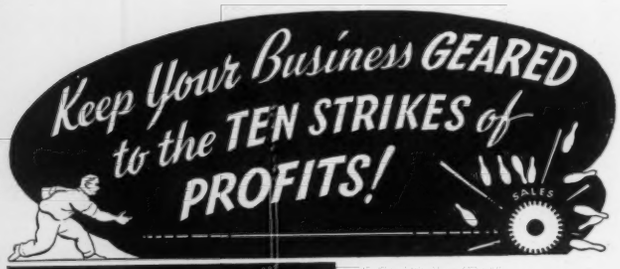
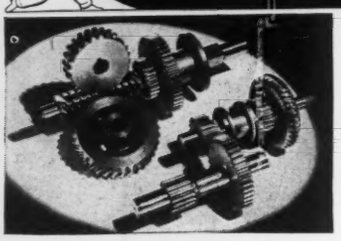
Headstock (left) and tailstock of Monarch Lathe with duplicate "LOGAN" Air Cylinders and Mandrels







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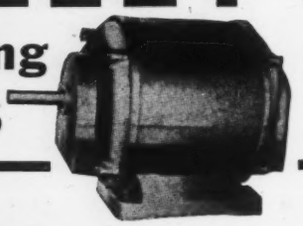

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Business and Sales Briefs

CONSTRUCTION of a new plant to produce synthetic phenol in Pittsfield, Mass., has been announced by W. H. Milton Jr., newly-appointed manager of General Electric Co. plastics department. Mr. Wilton replaces G. H. Shill. The new plant is being built at the request of the O.P.M. to counteract the shortage of phenol, a principal ingredient used in plastics. It is expected that the proposed plant will be in operation by September, 1942.

♦

At the recent 13th annual meeting of the Meehanite Research Institute of America Inc., Oliver Smalley, president of Meehanite Metal Corp., Pittsburgh, was elected president; H. B. Hanley, of American Laundry Machinery Co., Rochester, N. Y., vice president; and Frank M. Robbins, president of Ross-Meehan Foundries, Chattanooga, Tenn., secretary-treasurer.

♦

A slogan, "Waste Is Sabotage" has been created by the Indium Corp. of America, 60 East Forty-second street, New York. The corporation is distributing gummed labels featuring this watchword to plants, laboratories and other defense companies.

♦

Ruthman Machinery Co. has moved into its new plant and office at 1819 Reading road, Cincinnati. Two thousand coolant pumps a month is the capacity the company expects to be able to produce with its new facilities.

♦

With a membership comprising mostly all of the large plastic manufacturers, the Plastics Materials Manufacturers association has been established, with offices in the Tower building, Fourteenth and K streets, Washington. Arnold E. Pitcher of E. I. du Pont de Nemours & Co. is president; L. M. Rossi of Bakelite, vice president; and John E. Walker, secretary and treasurer. The organization aims to offer co-operation in utilizing plastics for defense purposes, to co-ordinate resources of member firms in a common effort, to promote safety measures and the general welfare of the plastics industry, to increase the use of plastic in arts and industries, and to study ways and means of eliminating all waste.

♦

Transfer of Frank A. Burnett to its Indianapolis office has been announced by Ampco Metal Inc., Milwaukee. Mr. Burnett, who previously was with the Cincinnati office of the company, will be located at 3335 College avenue, Indianapolis. E. A. Svoboda, located in the Indianapolis office, will take charge of Ampco's Cleveland office, replacing J. A. Morrison, resigned. Russell E. Campbell has joined the West Coast division.

♦

Announcement has been made by The Cold Metal Process Co., Youngstown, O., of the organization of a subsidiary company, The Cold Metal Products Co., which will take over the manufacturing operations formerly conducted by The Cold Metal Process Co. The manufacturing operations which have been incorporated into The Cold Metal Products Co. include

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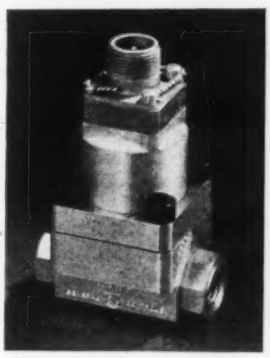

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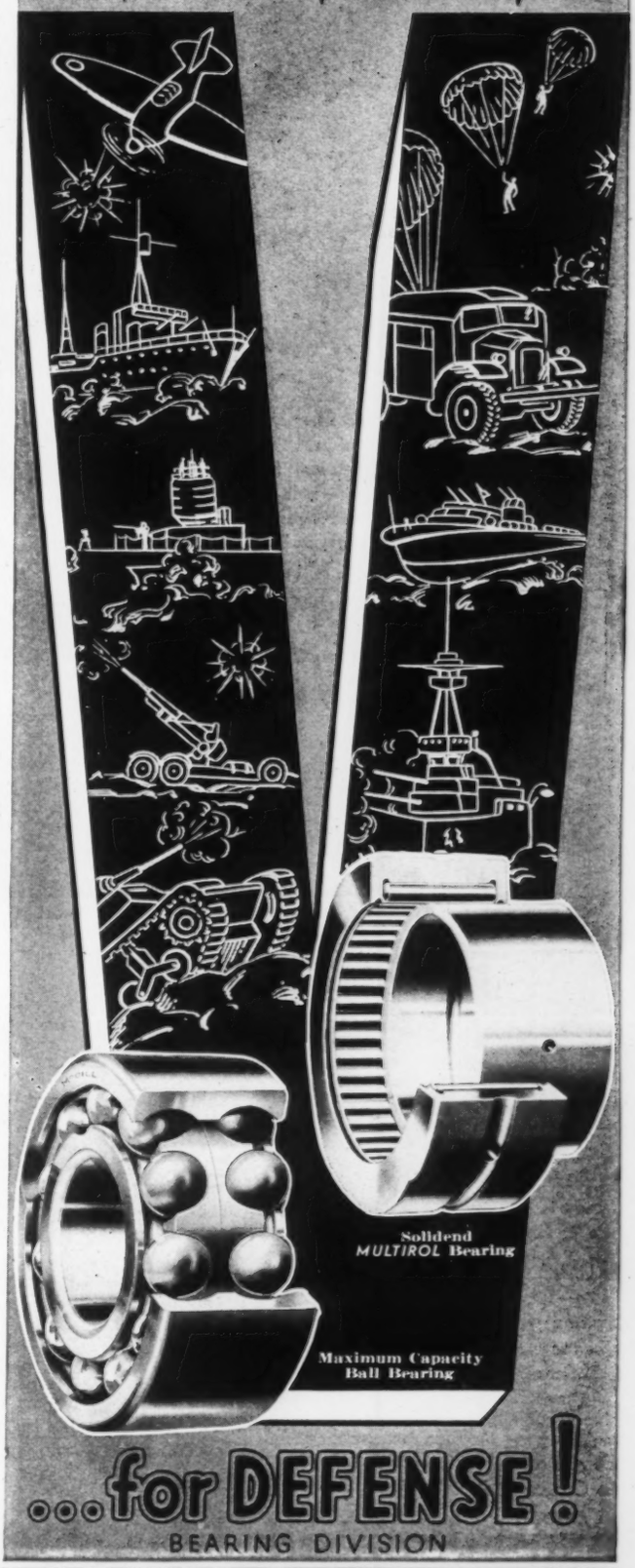

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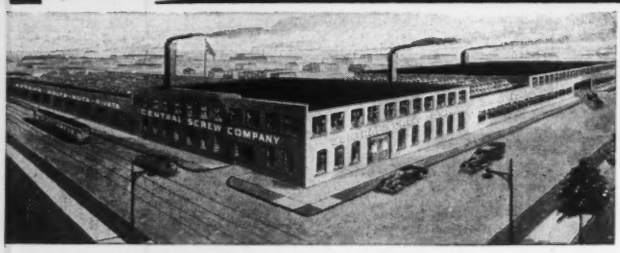

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two divisions: The designing and building of rolling mills and equipment and the strip steel division which produces special sizes and qualities of precision cold rolled strip steel.

♦

Formerly a special sales representative for La Salle Steel Co., Chicago, A. Frank Golick has been appointed assistant general manager of sales under T. L. Kelly, executive vice president in charge of sales. He has been associated with the steel industry in metallurgy and sales for over 20 years.

♦

Donald G. Dunn has been appointed assistant to vice president and general sales manager of Reynolds Metals Co. Inc., Richmond, Va. He was previously sales promotion and advertising manager of the company.

♦

Acme Industrial Co., 211 North Laflin street, Chicago, specializing in solving sealing problems, has formed a new department devoted exclusively to precision flat lapping. This new service will be of particular interest to manufacturers of equipment where fluids and gases must be sealed in by moving parts.

♦

Completion of a large scale plant expansion program has been announced by Arthur J. Schmitt, president, American Phenolic Corp. Defense orders are using 80 per cent of this firm's production, but with the increased manufacturing facilities, prompt delivery for civilian use will be made. The company's new address is 1830 South Fifty-fourth avenue, Cicero Post Office, Chicago.

♦

Construction of a new 84-inch, two-stand plate mill has been begun by Jessop Steel Co., Washington, Pa. This is part of a large plant expansion and modernization program undertaken by the company in the interests of National Defense. Also under construction is a new building for storage of raw materials. Two gas-fired annealing furnaces and a new ingot heating furnace have recently been installed.

♦

Expansion of its Watervliet, N. Y., plant is being made by Allegheny Ludlum Steel Corp. to increase its production of airplane valve steel. In addition, the company has broken ground recently for its new Brigham Road "Defense Plant" at Dunkirk, N. Y., also for the production of alloy steels for defense purposes.

♦

George B. Ewing Jr. has joined the sales engineering staff of the Foxboro Co. at its Houston office. Mr. Ewing has had wide industrial experience, particularly in the machine and tool-making industries and in petroleum refining operation. The St. Louis office of the company has been moved to the Continental building, 3615 Olive street.

♦

Romec Pump Co., Elyria, O., has been authorized by the Defense Plant Corp. to construct and equip a plant. The lease covers land and buildings for machinery and equipment.

♦

For the mid-western states, George P. Herrington has been appointed sales and engineering representative for the Lord Mfg. Co., Erie, Pa. His headquarters will be at 844 North Rush street, Chicago.

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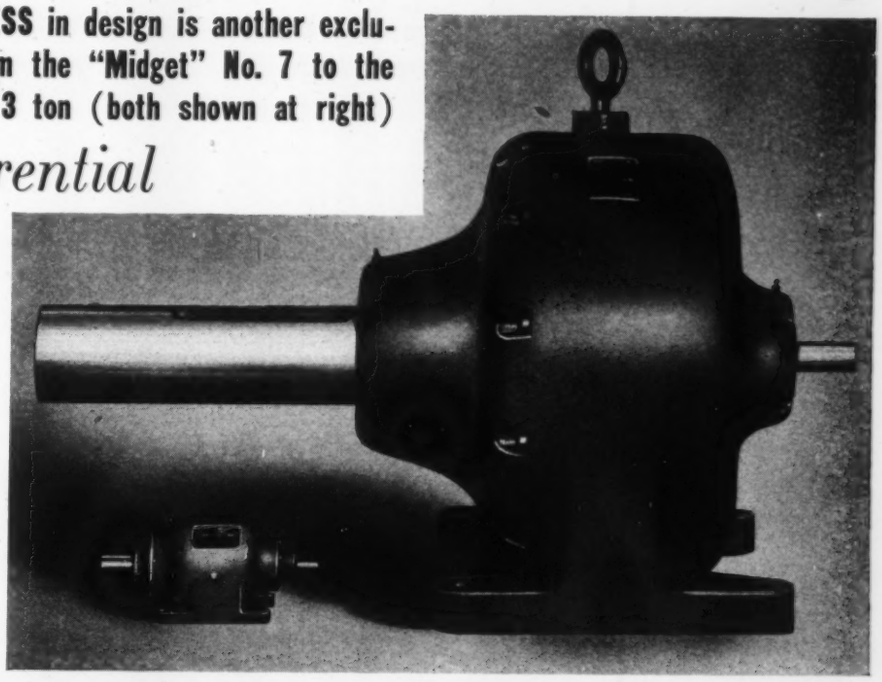
Horizontal and vertical types, motorized or without motors. Quiet-running helical gears assure smooth, positive power transmission. Low first-cost; low operating cost. In use in 47 industries. Our Engineering Dept. is at your service. Write us!



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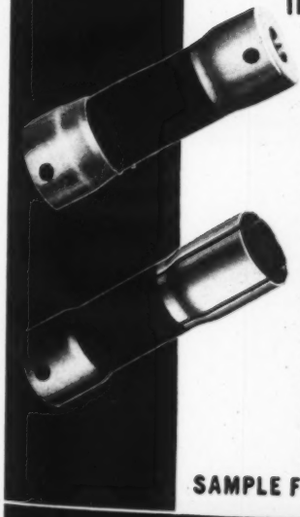
16 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK

NOTHING TAKES THE SHOCK LIKE RUBBER



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Features rubber cushion, made with *exclusive* oil-resisting treatment. Gripped permanently by die-cast ends.

Custom-made in various degrees of flexibility, engineered to job. Splined sleeve or standard types. Made any length from 2-1/2" up. Bores 5/16", 3/8", 7/16" and 1/2". Amazingly simple construction. No parts to get out of order, become noisy, or need replacement. More than a half million in service.

SAMPLE FOR TESTING ON REQUEST

GUARDIAN FLEXIBLE COUPLINGS
212 E. MICHIGAN ST.
MICHIGAN CITY, IND.

SHOW US..

YOUR COOLANT PROBLEM AND

WE'LL SHOW YOU..

A PUMP TO SOLVE IT!

RUTHMAN
GUSHER
COOLANT PUMPS

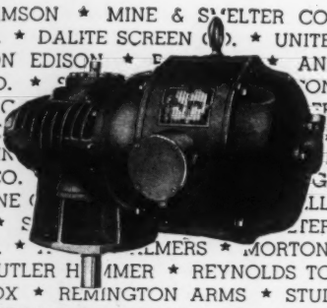
There's a Gusher Coolant Pump for virtually any machine tool made. There are motor driven models; belt driven models; plain drive models. Installation outside the reservoir, or for immersion in the reservoir. Small or large capacity models to suit the job. A Gusher model to *speed* your work. Write!

Model P3

P3 models are available in immersed type (1-P3), flange-mounted with internal discharge (2-P3), flange-mounted with external right hand discharge (3-P3), left hand discharge (4-P3). All above are available in short and long models, that is, for two maximum high water lines. Pat. and Pats. Pending

THE RUTHMAN MACHINERY CO.
1811 READING ROAD, CINCINNATI, OHIO
LARGEST EXCLUSIVE BUILDERS OF COOLANT PUMPS

STEPHENS-ADAMSON * MINE & SMELTER CO. * CARNEGIE-ILLINOIS STEEL * DALITE SCREEN CO. * UNITED POWER MFG. CO. * BOSTON EDISON * E... * ANNHEUSER-BUSCH BEMIS BAG CO. * S... CONTINENTAL CAN IDEAL ROLLER C... EL * AMERICAN ARMAMENT CO... EO. T. SCHMIDT PETERS MACHIN... INTERNATIONAL RESISTANCE CO. ... G. CO. * NEW JERSEY MACHINE C... LL & MOORE, INC. ELLIOTT CO. * S... TER KIDDIE & CO. ALUMINUM CO. * ...LMERS * MORTON SALT * WARD LEONARD * CUTLER H...MER * REYNOLDS TOBACCO * BABCOCK & WILCOX * REMINGTON ARMS * STUDEBAKER * DUPONT * GOODYEAR * GOODRICH * NEW DEPARTURE * HYATT TOLEDO SCALE * KOHLER CO. * SCRIPTO * FRANKFORD ARSENAL * DELCO-REMY * DE LAVAL, LTD. * CORNING GLASS BENDIX AVIATION * AGFA ANSCO * HAYS CORP. * WESTERN ELECTRIC * G... REQUESTER * U.S. NAVY * LIBBY OWENS FORD * CHAMPION SPARK PLUG * ELECTRIC AUTO-LITE * LINK-BELT * ZAHM & NAGEL * PROCTOR & SCHWARTZ OWENS ILLINOIS GLASS * U. S. COAST GUARD * E. G. BUDD LEEDS & NORTHRUP * BARRY WEHMILLER MACHINE CO. OWENS CORNING FIBERGLAS * CAMERON CAN MACHINE CO. COMBUSTION ENGINEERING * BRAUER... * ... CREAMERY PACKAGE * ENERGY ELEVATOR * R. HOE & CO. * HERCULES POWDER * HEYDON CHEMICAL CORP. * SPENCER TURBINE U. S. SIGNAL CORPS. * E. W. BLISS * SKF INDUSTRIES WRIGHT AERONAUTICAL * BRADY CONVEYOR * AJAX ELECTRIC FURNACE * MATHEWS CONVEYOR * AMERICAN OPTICAL FO... MACHI... INTERNATIONAL ... STEARNS ROGERS * STACKPOLE CARBON * RUSTLESS IRON & STEEL * PERMUTIT CO. * JEFFREY MFG. CO. * AMERICAN VISCOSE * STANDARD CONVEYOR * AMERICAN LAVA CO. DOUGLAS AVIATION * PHOTO ELECTRIC PILOT * NATIONAL CARBON CO. * OLSON RUG CO. * SCHULZE BAKING CO. INTERNATIONAL FILTER CO. * AUTOMATIC ELECTRIC * DYER



LARGE and SMALL

THEY all INSTALL

Janette Speed Reducers

Janette Manufacturing Company
556-558 West Monroe Street Chicago, Ill. U.S.A.

METALLIC BELLOWS
FOR AUTOMATIC HEAT CONTROL

We manufacture bellows and bellows assemblies ready for installation in steam traps, relief valves, temperature regulators, pressure regulators, air valves, and other automatic temperature and pressure controls. Complete engineering service.

Produced Hydraulically by

CLIFFORD MANUFACTURING CO.
564 E. FIRST STREET, BOSTON
BOSTON CHICAGO DETROIT LOS ANGELES
PRODUCERS OF BELLOWS EXCLUSIVELY
SERVING AUTOMATIC CONTROL MANUFACTURERS

Additional personnel will be added to take care of the increased territory including Illinois, Indiana, Iowa and Missouri.

♦

Erection of a new shop for manufacturing reduction gears at the Lynn River Works of General Electric Co. is now officially underway. It is scheduled to be completed by January 1 and is expected to be turning out gears in quantity by June.

Meetings and Expositions

Dec. 1-6—

Exposition of Chemical Industries. Biennial exposition to be held at Grand Central Palace, New York. Charles F. Roth, Grand Central Palace, New York, is manager.

Dec. 9-10—

American Management association. Conference to be held at Statler hotel, Cleveland. Additional information may be obtained from Carl Heyel, 330 West Forty-second street, New York.

Dec. 10—

American Standards association. Annual meeting to be held in New York. Additional information may be obtained from the association headquarters at 29 West Thirty-ninth street, New York.

Dec. 10-11—

Mississippi Valley Farm Equipment association. Annual meeting to be held at DeSoto hotel, St. Louis. W. V. Jeans, 206 Hotel DeSoto, St. Louis, is secretary.

Jan. 12-15—

Refrigeration Equipment Manufacturers association. All-industry refrigeration and air conditioning exhibition to be held at Stevens hotel, Chicago. Additional information may be obtained from Theodore R. Sills, 43 East Ohio street, Chicago.

Jan. 15—

American Railway Car institute. Annual meeting to be held in New York. Additional information may be obtained from W. C. Tabbert, secretary, 19 Rector street, New York.

Jan. 21—

Aluminum association. Annual meeting to be held at 420 Lexington avenue, New York, Kenneth G. Castleman, at the foregoing address, is secretary of the association.

Jan. 26-28—

National Warm Air Heating and Air Conditioning association. Annual meeting to be held at Benjamin Franklin hotel, Philadelphia. George Boeddener, 145 Public Square, Cleveland, is managing director.

Jan. 26-29—

American Society of Heating and Ventilating Engineers. Annual meeting and exposition to be held at Bellevue-Stratford hotel, Philadelphia. A. V. Hutchinson, 51 Madison avenue, New York, is secretary.

Jan. 26-30—

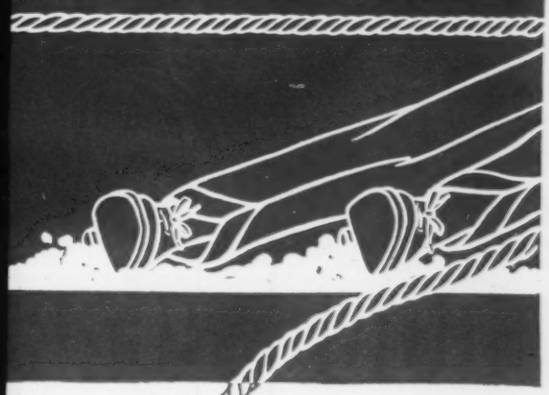
American Institute of Electrical Engineers. Annual winter convention to be held at Engineering Societies building, New York. H. H. Henline, 33 West Thirty-ninth street, New York, is secretary.

Feb. 5—

National Electrical Manufacturers association. Annual meeting to be held at Palmer House, Chicago. R. J. Blais, 155 East Forty-fourth street, New York, is convention manager.

Engineering Library

equal to the TUG OF WAR



As the chisel edges of EverLOCK washers dig in to resist the tugs and pulls of vibration or shock, your product proves itself equal to the severest tests. Today, particularly, few manufacturers can foresee exactly how severe the conditions to be met will be. Soundest policy is to bolt or screw every assembly to be ready for the worst.

With EverLOCK washers this is easy and economical — and represents a higher standard of manufacture at no greater cost. The difference is chiefly in the washer design which gives several times more area of resistance (see illustration) with this tooth type washer than with others. The principle is that used by a man who, in a tug of war, braces the whole side of each foot against the earth rather than his heel alone.

Get the handy catalog which shows the whole line at a glance. Just write for it and for an EverLOCK demonstration on your product.

SIX STANDARD TYPES
IN 91 SIZES

FOR MOST APPLICATIONS

Ever LOCK WASHERS

OVER 100 SIZES AND TYPES FOR SPECIAL APPLICATION

THOMPSON-BREMER & CO., 1640 W. HUBBARD ST., CHICAGO, ILL.

"PERFECT" Oil Seals

GOOD BEARING PROTECTION

A Plus Value of the Well Engineered Machine Tool

No machine tool is better than its bearings, and no machine tool element is subjected to more critical operating conditions. Consequently, the lasting value of the machine tool depends largely on minimizing wear in its bearings.

When you prevent the leakage of bearing lubricant and exclude all foreign matter from the bearing housing you remove the two worst enemies to good machine performance.

"Perfect" Oil Seals provide precisely that protection. The machine tool so equipped requires fewer bearing adjustments, retains truer bearing alignment, turns out more accurately machined product, and operates with maximum economy of lubricant, power, bearing maintenance and bearing replacement.

Assure the user of your machine tools these plus values. Let Chicago Rawhide engineers suggest the most effective type of seal for the special requirements of your machine.

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 13 DECEMBER 1941 Number 12

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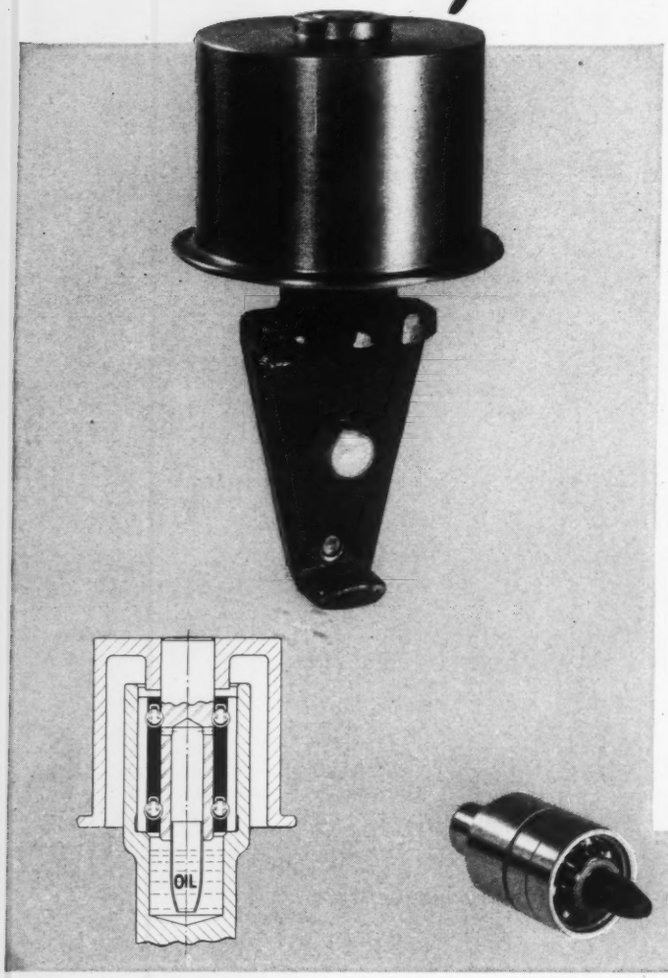
inside it's always *raining*



● Yes, a continuous shower of tiny drops of oil inside this Tension Pulley Ball Bearing keeps balls and raceways automatically lubricated. It is the *first* anti-friction bearing with its own oil-circulating system—a permanent built-in feature, enabling it to run for a year or more without attention.

Since the products of New Departure are *ideas* as well as ball bearings, this company has developed many "famous firsts," has revolutionized mechanical design in many industries.

Nothing rolls like a ball. Ball bearings are used wherever shafts turn. Ask for your copy of that absorbing, superbly illustrated treatise: "Why Anti-Friction Bearings." New Departure, a division of General Motors, Bristol, Connecticut. Chicago and Detroit.

New Departure

. . THE FORGED STEEL BEARING

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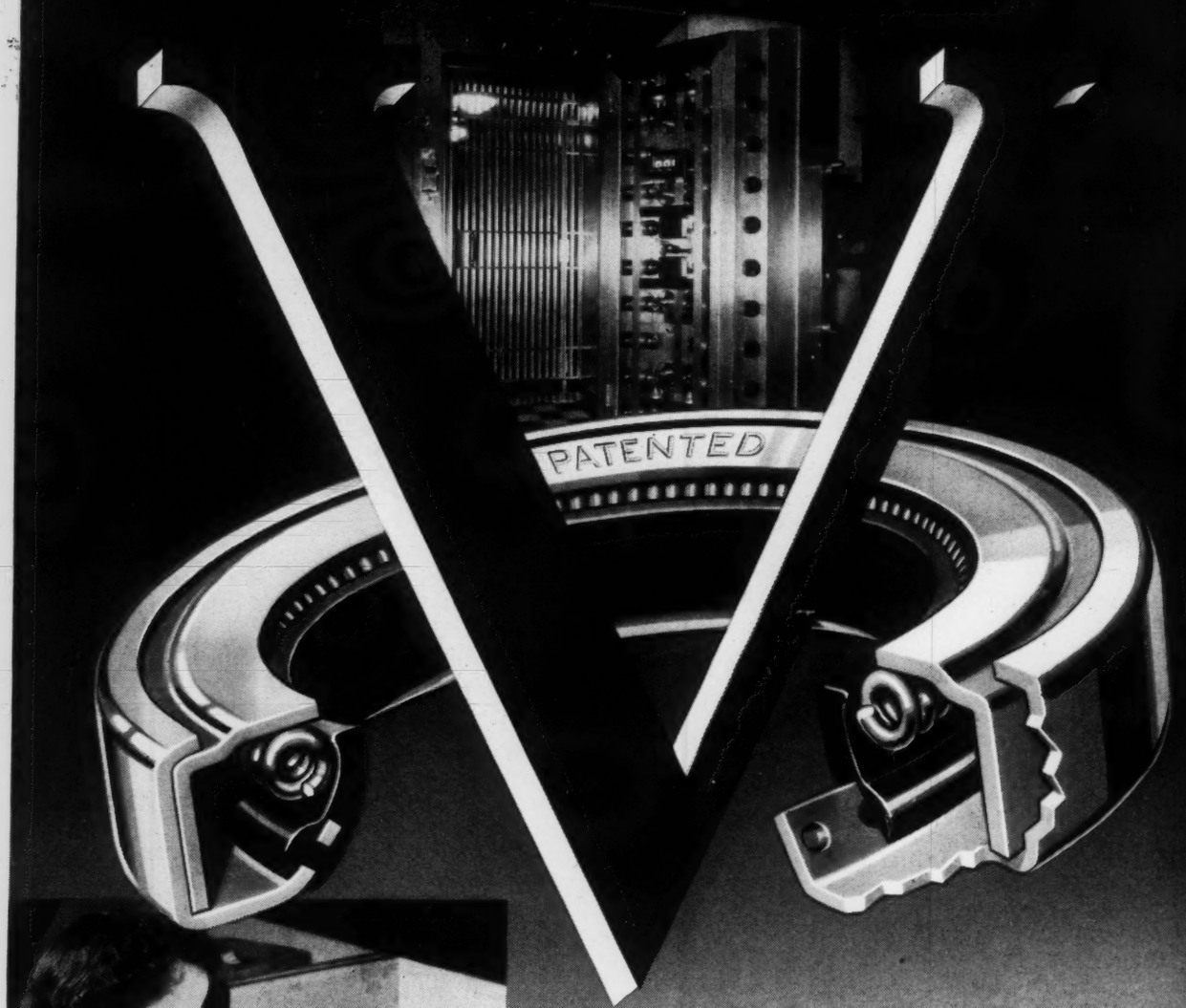
WHY VICTOR LEADS



PROTECTION

Your protection against loss of wealth is the great steel door of the modern safety vault, weighing tons, yet poised lightly on its bearings.

Your protection against loss of lubricant vital to bearing performance is the Victoprene Oil Seal, skillfully designed and accurately finished—with its modern synthetic sealing element bonded to the metal shell. For safety, specify Victoprene Oil Seals. Victor Manufacturing & Gasket Co., P. O. Box 1333, Chicago, Illinois, U. S. A.

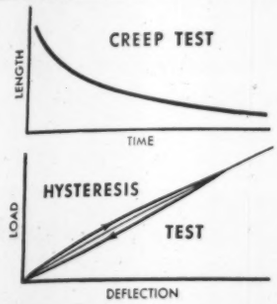
WORLD'S LARGEST GASKET MANUFACTURER

VICTOR

GASKETS • OIL SEALS • GREASE RETAINERS • SHEET PACKING • GASKET COMPOUNDS

Springs get the CREEPS—This Measures Them

SPRING NEWS

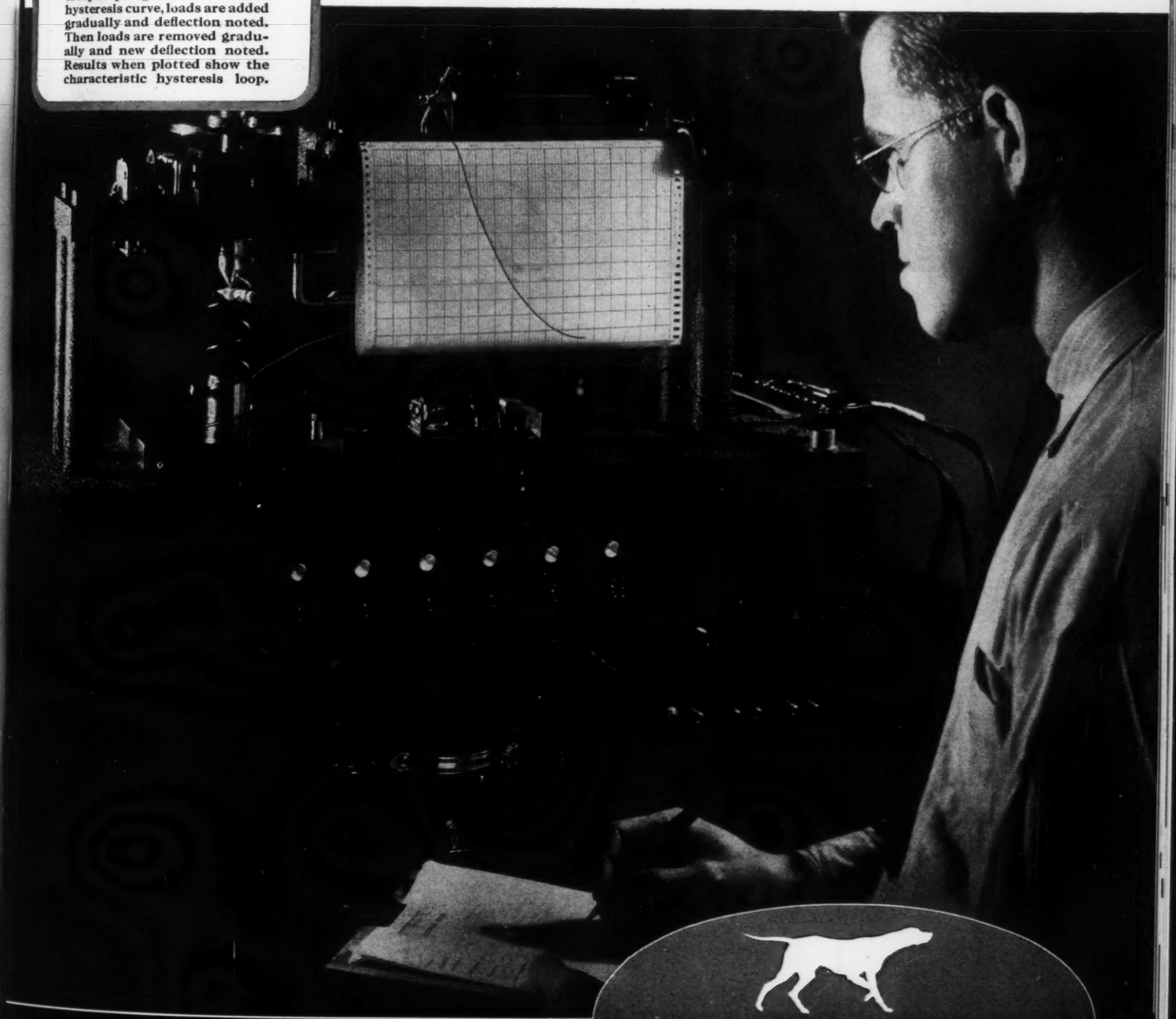


In the creep test a fixed load is applied and the subsequent creep of spring recorded. To chart hysteresis curve, loads are added gradually and deflection noted. Then loads are removed gradually and new deflection noted. Results when plotted show the characteristic hysteresis loop.

FOR A LONG TIME it has been known that a slow plastic flow takes place in metals subjected to a constant load at elevated temperatures. Engineers have a word for it. They call it "creep". Creep has a pretty important bearing on certain precision applications. And, since precision springs are Hunter's business, Hunter naturally wanted to find out all it could about the effects of creep on spring metals.

Thus an entirely new kind of automatic creep testing machine was evolved and built in the Hunter laboratories. This machine is a super-sensitive motion recorder which uses electronic detectors to shadow every micrometric change in length; enlarges them; then charts them plainly. More than that—*it even records its own errors automatically*—and presents for observation an accurate picture of hysteresis and elastic recovery, two other factors of value in perfecting spring performance.

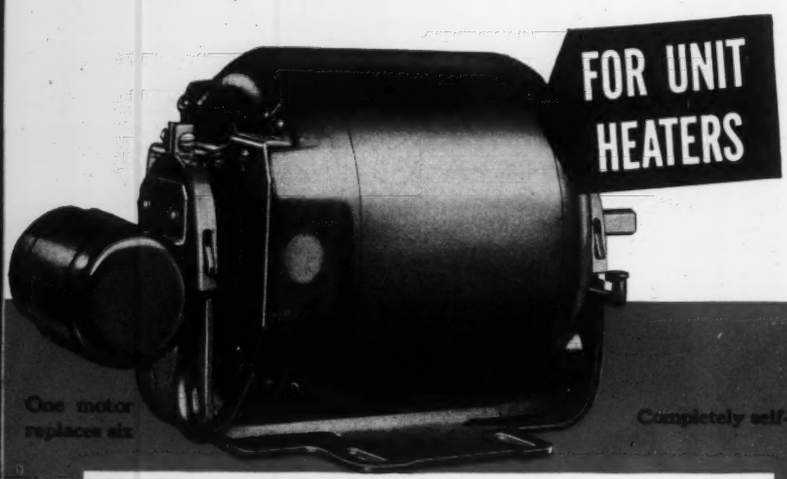
The "creep" test machine is one of the means which Hunter uses to take the guesswork out of spring making, to develop new uses for springs, to improve springs for present applications.



HUNTER
Science in Springs

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.

Westinghouse

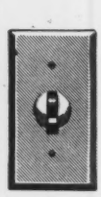


One motor replaces six

Completely self-protected

PROBLEM—Unit heater manufacturers were using six different motors to meet requirements for constant, two-speed, and multi-speed operation on both 115 and 230-volt circuits. To reduce stocking, to speed production, to open new markets, they wanted simplification.

SOLUTION—Westinghouse unit heater specialists designed a dual-voltage motor suitable for all three operating conditions. Now, one motor takes the place of six and provides, in addition, other special advantages—"no bump" bearings, quiet operation, extra flexibility of mounting.



This ordinary on-off switch gives single speed on either 115 or 230 volts.

This inexpensive switch gives two speeds on either 115 or 230 volts, without transformer or change in motor.

This low-cost self-contained speed controller gives multi-speed operation on either 115 or 230 volts without change in motor.

Available from 1/20 to ¾ hp for band or resilient mounting, floor or ceiling, this special motor is used by more unit heater manufacturers than any other make.

PROBLEM—Most householders lack mechanic knowledge. Therefore, stokers require motors com pletely self-protected against the application's ex treme hazards—immune to burnout from clogge feeds, excessive temperatures, improper ventila tion and overloads—self-starting after low voltag —dust-free.

SOLUTION—Westinghouse stoker specialists de signed this capacitor-start, Thermoguard-protected totally-enclosed motor to completely eliminat stoker drive worries. Thermoguard interrupts cir cuit the instant abnormal load, current, or hea conditions arise, automatically restores circuit when safe temperature is reached—may be used t operate bell alarm, if desired.

CLICK! IT'S OFF!
Simple, Bi-metal, Thermoguard disc opens circuit with rifle-bullet speed when motor temperature reaches danger point.

CLICK! IT'S ON!
With return of safe conditions, Thermoguard restarts motor automatically.

ARRANGED FOR HANDY BX CONNECTOR
Conduit box is fitted with a removable plug permitting use of standard BX conduit for wiring motor.

Available in sizes from ⅓ to ¾ hp at all standard speeds for either 110 or 220 volts (dual voltage above ¼ hp) with rigid or resilient mounting.

WESTINGHOUSE

Westinghouse

helps industry move ahead!

Capacitor and cable connection mounted inside base

...WITH MOTORS SPECIALLY DEVELOPED FOR SPECIALIZED PRODUCTS

Westinghouse pioneered the small a-c motor fifty years ago, thereby assuming the leader's responsibility for continued development in the small motor field.

And down through the years, as a tenet of that responsibility, Westinghouse has built up a corps of specialized engineers which devotes itself solely to the development of special motors for special industries. For example, many Westinghouse engineers spend their entire working time solving the specific problems of the Unit Heater industry . . . other engineers dedicate their efforts to Stoker manufacturers . . . while others work exclusively on Jet Pump motors.

This engineering organization makes available special motors perfectly adapted for use with your specialized product . . . makes it a desirable move to consult Westinghouse first, relative to your Small Motor needs.

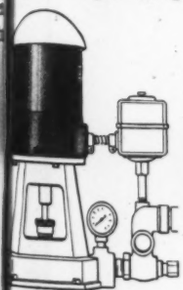
We will consider it a privilege to serve you and to solve for you problems like those listed in the adjoining column—problems which we have solved for manufacturers of Unit Heaters, Stokers and Jet Pumps.

- **For Unit Heater information, write for F-8485.**
- **For Stoker Motor Data, send for F-8489, F-8490.**
- **For Jet Pump Facts, consult your Westinghouse representative.**

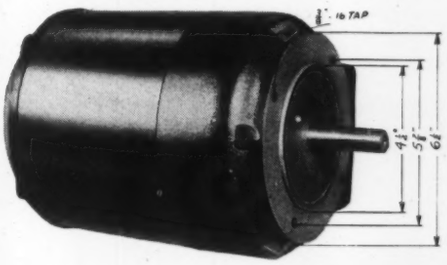
J-03138

PROBLEM—Nothing was basically wrong with flange-mounted jet pump motors—but adoption of standard mounting dimensions by NEMA necessitated minor design changes. To Westinghouse specialists the situation presented an opportunity to streamline the motors to the application.

SOLUTION—Using the new NEMA dimensions as a base—Westinghouse specialists built up an entirely new, advanced design with capacitor and conduit box built-in to the lower bracket to improve appearance, make connections shorter and more convenient, and provide greater protection to capacitor.



Standardized Flange Mounting Motor applied to jet pump. Capacitor now mounted inside lower bracket for better appearance and protection. Lower bracket location of conduit box more convenient, better looking, and shortens conduit required.



Both frame 145 and frame 186 now made in ball-bearing construction, all types and ratings, for flange mounting with these new NEMA dimensions.

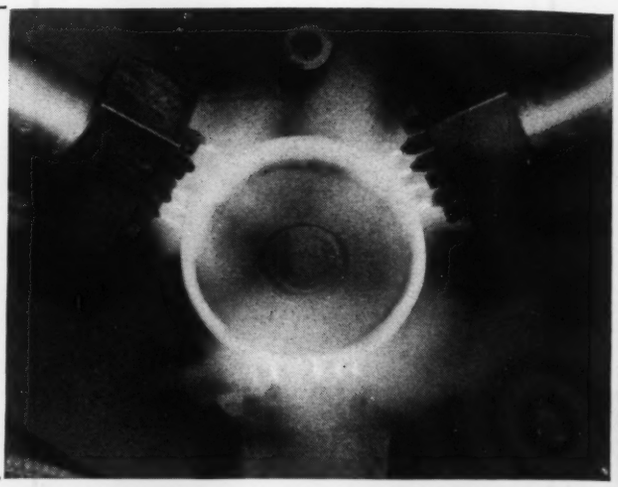
Available in standard flange mounting and ball-bearing construction for all ratings in the Westinghouse 145 and 186 series frames, and for rigid foot mounting.

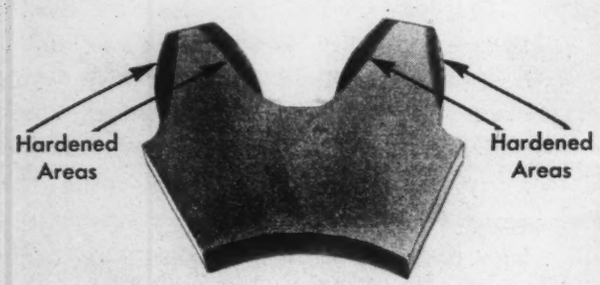
SMALL MOTORS

OXY-ACETYLENE FLAME-HARDENING makes wearing parts last longer . . .

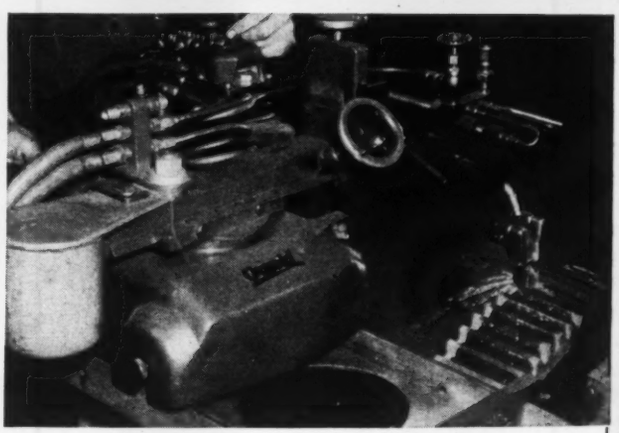
1. What it is and how it's done

Oxy-acetylene flame-hardening imparts a hard case to wearing parts to make them last longer. This is done by heating the area to be hardened with oxy-acetylene flames, and then quenching with water or oil. Commonly used steels and high-tensile cast iron can be flame-hardened successfully. Small areas can be hardened by the "spot" method, using a hand welding blowpipe. Larger areas are usually hardened by mechanized equipment, using the "progressive" method or—as shown in the illustration at the right—the "spinning" method.





Unretouched view of etched cross section of a flame-hardened gear tooth.



2. What its advantages are

In many cases, oxy-acetylene flame-hardening is not only the best method, but the *only* practical method. Some of its advantages are:

- Parts of any size or shape can be hardened.
- There is no appreciable distortion.
- Toughness of the core is unaffected.
- Chemical composition of the metal is unchanged.
- Penetration can be closely controlled.
- The hardened area does not spall off.
- It permits use of cheaper base metals.
- Only a moderate equipment investment is required.

3. Typical parts being hardened

In the illustration above, Oxweld flame-hardening equipment is being used to impart a hard case to the teeth of a crane gear — at only the points where wear occurs. A few of the many other parts which are hardened—or fabricated—with the help of this oxy-acetylene process are:

Sprockets	Cams	Piston Rods
Dies	Crane Wheels	Pump Plungers
Sheave Wheels	Bearing Raceways	Crossheads
Shear Blades	Shafts	Saw Blades

Linde can supply the gases, the apparatus, and help in using flame-hardening. If you are interested in giving longer life to wearing parts, *talk it over with Linde!*

THE LINDE AIR PRODUCTS COMPANY

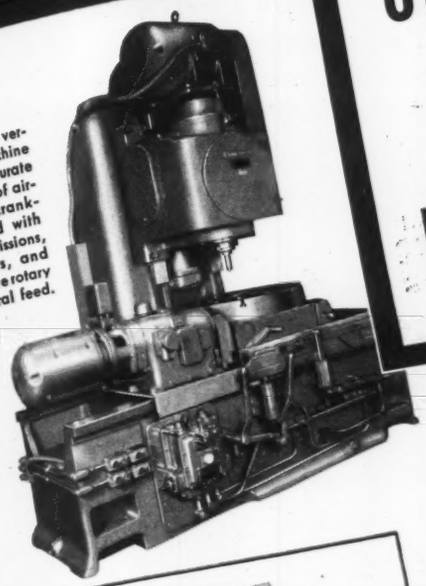
Unit of Union Carbide and Carbon Corporation

General Office: New York, N. Y. Offices in Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

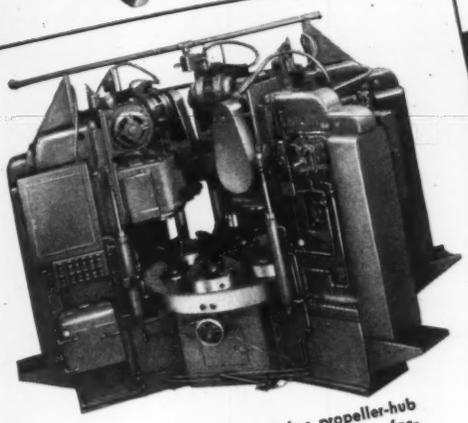
LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.

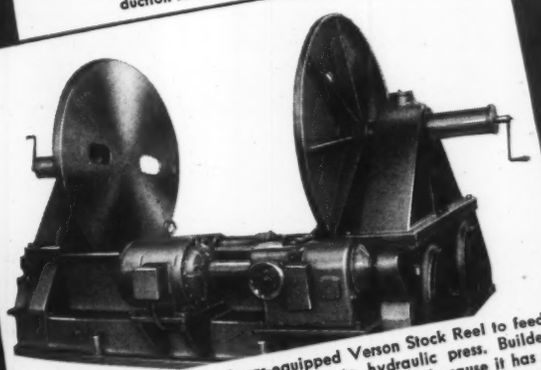
OILGEAR FLUID POWER HELPS YOU ANSWER *Vital* MACHINE DESIGN PROBLEMS



Davis & Thompson vertical milling machine for high speed accurate milling of inside of airplane engine crankcases. Equipped with Oilgear Transmissions, Pumps, Valves, and Cylinders to drive rotary table and lateral feed.



Five Oilgear Units in this Baker propeller-hub drilling machine perform 5 steps of drilling, facing, and chamfering to speed up propeller production for defense.



Oilgear-equipped Verson Stock Reel to feed cold-rolled strip to hydraulic press. Builder says: "We selected Oilgear because it has a range beginning at absolute zero and continuing up to maximum feed; also may be smoothly and almost instantly reversed."

FOR ease of power transmission application, for versatility of installation, for maximum production of your machines, for long, troublefree operation in the field . . . your best answer is Oilgear Fluid Power Pumps, Motors, Transmissions, Cylinders, and Valves. Note the varied applications of Oilgear shown on this page; they are a trifling few of the many tough machine design problems solved by manufacturers in many fields.

Oilgear Fluid Power Systems are compact, simple, easy to install. They present smashing advantages over mechanical drives and other hydraulic systems. They may be used with any kind of drive—belt, chain, gear, or direct—and require a minimum of piping and space. They offer a wide range of standard sizes and controls permitting you to custom-fit Oilgear Systems to the speed, power and function specifications of practically any machine. Speeds are steplessly variable from zero to maximum in either direction; ratios between feed and rapid traverse are high; feed speeds can be controlled with *micrometer* accuracy; reversals are fast, cushioned and controlled; lubrication is automatic with Oilgear Fluid Power Units. Pre-set operating speeds in either direction, remote control by push-button stations and automatic pressure unloading are a few of the advantages of the many different types of Oilgear standard controls.

The superior performance and dependability of Oilgear Fluid Power Systems have proved out on the toughest defense schedules. From your standpoint and your customers' it is the most economical and efficient answer to the power problems of your machines. Complete technical data is yours for the asking. Just indicate on the coupon whether you want information about Oilgear Pumps, Motors, Transmissions, Cylinders, Valves, or all of them. THE OILGEAR COMPANY, 1310 West Bruce Street, Milwaukee, Wisconsin.

Feeds • Pumps • Cylinders • Valves • Motors • Transmissions
Horizontal and Vertical Broaching Machines • Horizontal and Vertical Presses • Custom Built Machines

OILGEAR

Trademark Reg. OILGEAR U. S. Pat. Off.

THE MOST EFFECTIVE APPLICATION OF *fluid power*

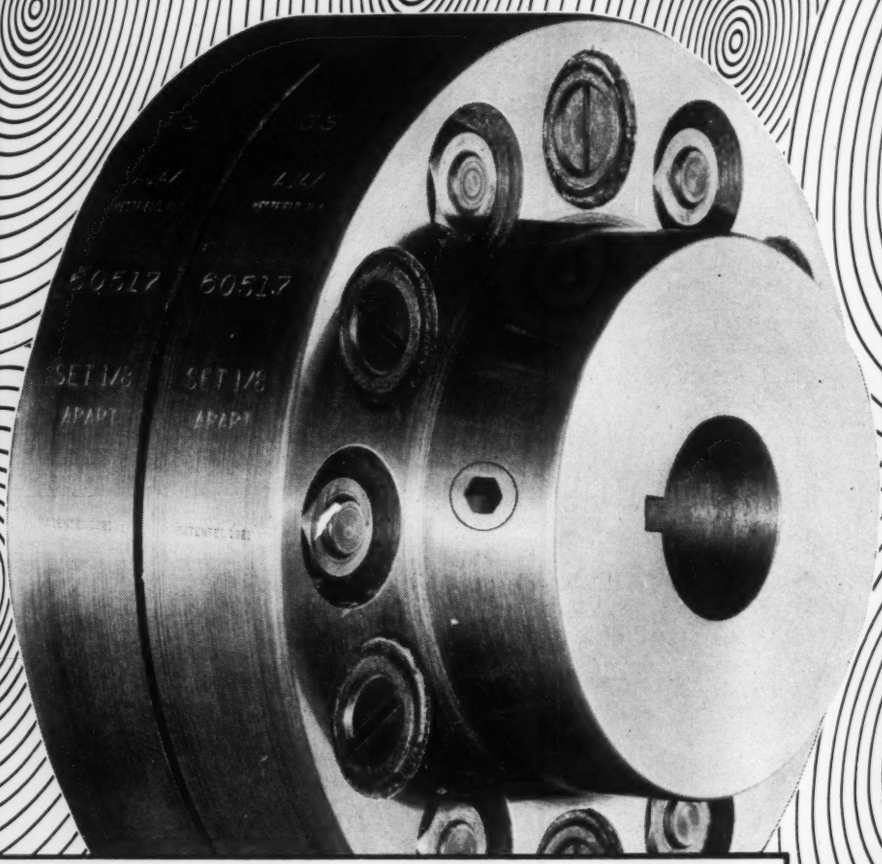
THE OILGEAR COMPANY, 1310 W. Bruce St., Milwaukee, Wisconsin
Please send information about ☐ Pumps and Motors, ☐ Transmissions, ☐ Cylinders, ☐ Valves.

Name .....

Company .....

Address .....

City ..... *State* .....

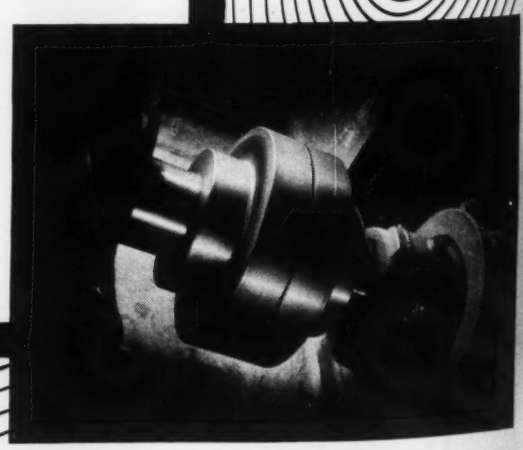


Keep The Wheels Turning With

AJAX FLEXIBLE COUPLINGS

This is no time for shutdowns! Safeguard the performance of the machines you design and build with Ajax Flexible Couplings as your standard equipment. Their exclusive, rubber bushed, bronze bearings combine positive drive, resilient protection against misalignment, free end float, no lubrication problem, no noise, no backlash. Sizes from ½ inch bore up. Write for Catalog. Sales Offices in all principal cities . . . Look for Ajax in your phone book.

All the horsepower goes through this Ajax Coupling in the main power drive of a large flour mill as shown at right.



AJAX FLEXIBLE COUPLING CO.
102 ENGLISH ST. **WESTFIELD, N. Y.**

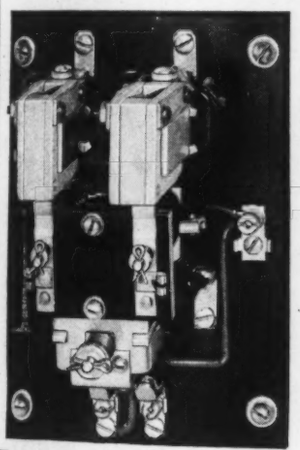
Even your children will be interested in making these wheels keep turning. Write for reprints of this ad.

3 New Sizes—

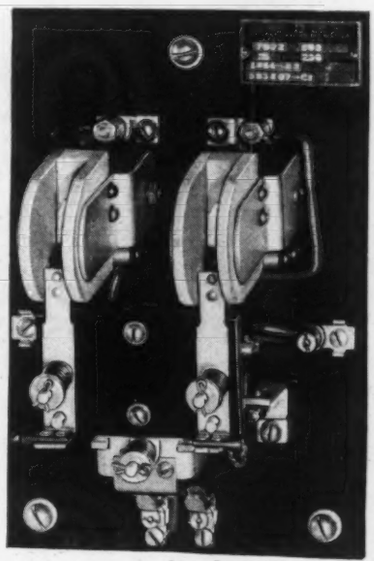
SQUARE D

HEAVY DUTY D·C·CONTACTORS

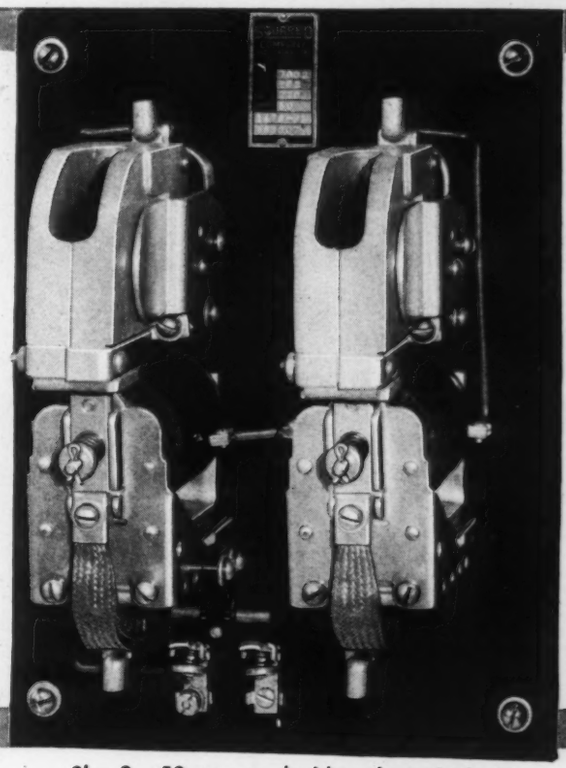
CONSTRUCTION AND PERFORMANCE COMPARABLE TO LARGER APPARATUS



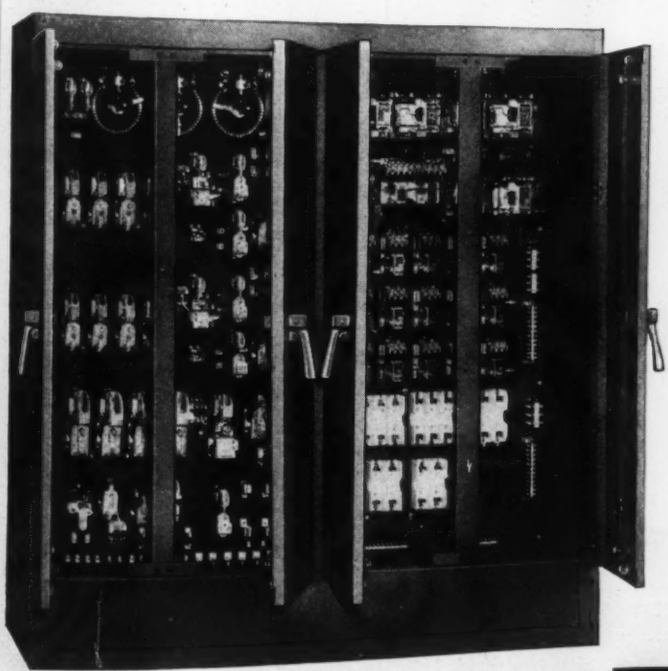
Size 0
15 ampere contactor



Size 1
25 ampere contactor



Size 2—50 ampere double pole contactor.
One of six sizes available



D.C. and A.C. control, side by side, in this special machine tool panel.

CALL IN A SQUARE D MAN

THE increasing use of direct current for machine tool control and mill equipment calls for D.C. contactors in the smaller ratings but with construction and performance features expected of larger mill type apparatus. Square D has therefore added 15, 25 and 50 ampere D.C. contactors to its present line of 100, 150 and 300 ampere equipment. The same design has been followed as far as is consistent and these smaller units offer important advantages in mounting space and lower cost.

Similarly designed, spring closed contactors for dynamic braking are available in equivalent sizes. Time limit, current limit or C. E. M. F. acceleration can be used. Field accelerating or decelerating, plugging or anti-plugging, field loss, voltage sensitive and undervoltage relays have all been added to "round out" the line. From these component parts all types of standard and special D.C. controllers can be assembled with maximum utility and minimum expense.

In performance, Square D's new and complete D.C. control line equals the A.C. equipment which is so popular in the machine tool and other fields where service is severe. Together they provide the solution to most industrial control problems.

There are Square D offices with field engineering service in all industrial centers.

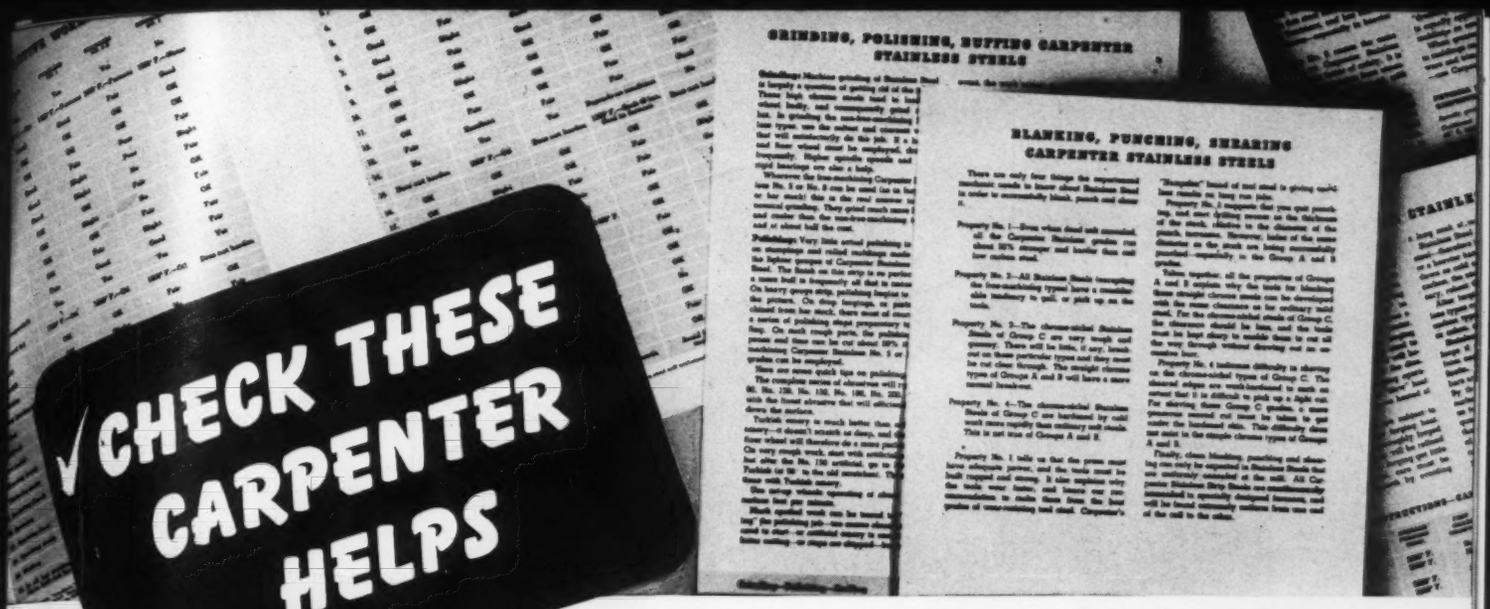
SQUARE D COMPANY

DETROIT - MILWAUKEE - LOS ANGELES

KOLLSMAN INSTRUMENT DIVISION, ELMHURST, NEW YORK

IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO

For
Summary of
TECHNICAL DATA OF
Carpenter
STAINLESS STEELS
HANDY SELECTOR SLIDE CHART
This convenient pocket-sized guide will help you spot the Stainless analysis which best meets your Corrosion or Heat Resistance requirements. It quickly answers questions involving physical properties, and fabricating conditions.
FOR
quick answers
TO YOUR
STAINLESS
FABRICATING
PROBLEMS
WELDING AND RIVETING CARPENTER STAINLESS STEELS
TUMBLING, BALL BURNISHING CARPENTER STAINLESS STEEL
FORMING, DRAWING, SPINNING, COLD HEADING CARPENTER STAINLESS STEELS
MACHINING CARPENTER STAINLESS STEELS
PICKLING CARPENTER STAINLESS STEELS
SOLDERING CARPENTER STAINLESS STEELS
DESIGN
GUIDE FOR THE DESIGN ENGINEER
Whether designing for new defense applications, or to meet tomorrow's sales problem, this booklet will help you. It shows practical ways and means of designing for Stainless—how to take advantage of the added strength and rigidity of Stainless Steel—how to design for faster and easier fabrication.
Carpenter
BRANCHES AT Chicago, Cleveland



✓CHECK THESE CARPENTER HELPS

WHEN you are up against a new or difficult fabrication problem these days, you know how important it is to find the right answer quickly. Getting it right the first time can save precious hours and days, and much vital material that is needed for national defense.

Helping Stainless users to solve fabricating problems is no new job to us at Carpenter. Ever since we pioneered the first bright finish, ductile Stainless Strip . . . ever since Carpenter's original development of free-machining Stainless . . . our representatives, metallurgists and research men have been in the front line when it comes to meeting new problems.

Out of it all has come the "know how" which time after time has helped us to make the "impossible" job, possible. In keeping with Carpenter's established policy of sharing its knowledge and experience with its customers—this information has been released in printed form from time to time.

It is available to any user of Stainless Steel who would like additional fabricating information based upon the experience and research of a group of men that have pioneered in the production of Stainless Steel.

THE CARPENTER STEEL COMPANY
READING, PA.

STAINLESS SELECTOR SLIDE CHART ☐

DESIGN BOOKLET ☐

STAINLESS DATA SHEETS

Each subject is condensed into a single sheet of data covering the particular operations mentioned. Check the problem on which you would like information.

- Machining ☐
- Blanking, punching, shearing ☐
- Forming, drawing, spinning, cold heading ☐
- Grinding, polishing, buffing ☐
- Tumbling, ball burnishing ☐
- Soldering ☐
- Welding and rivetting ☐

A request on your company letterhead will bring you any of these Carpenter Stainless helps promptly.

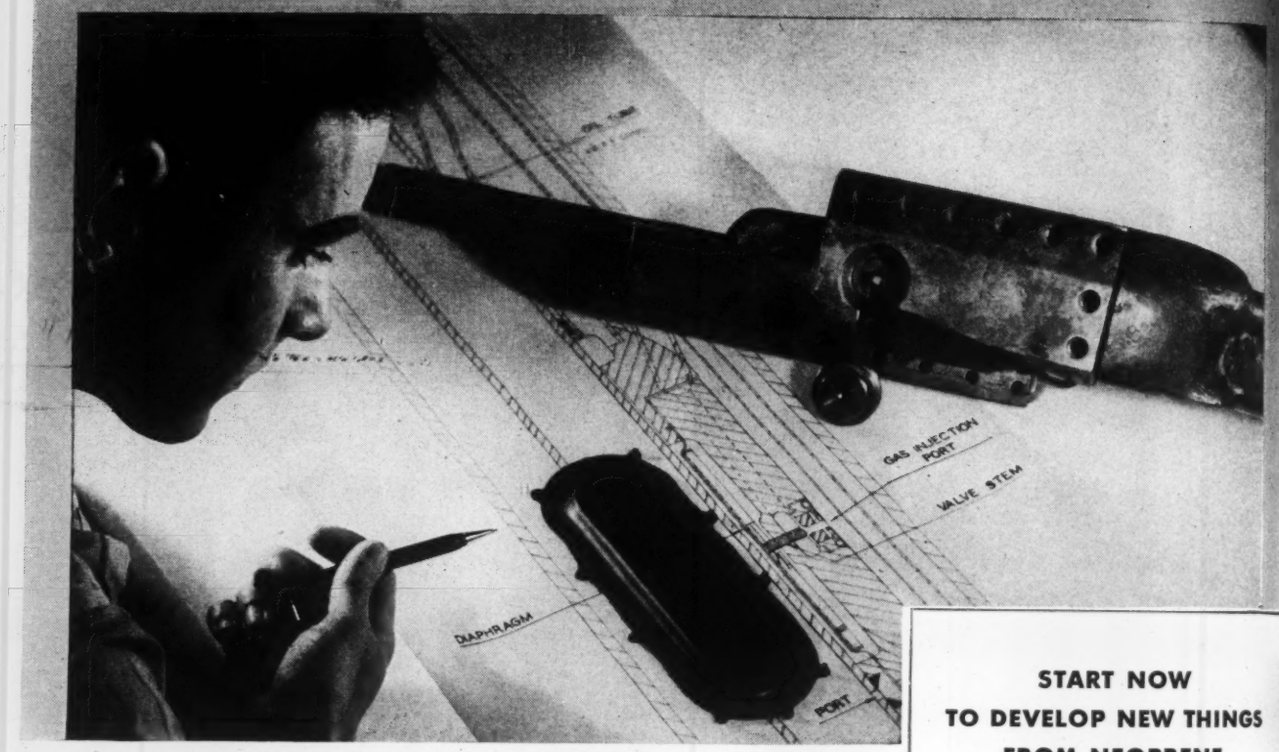
THE CARPENTER STEEL COMPANY
105 BERN ST., READING, PENNA.

STAINLESS STEELS

more than corrosion resistance

Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

THE TOUGH INTERMITTER WITH A HEART OF NEOPRENE!



Diaphragm of the McEvoy Fluid Weight Intermitter, pictured individually and in working position. Photograph and story courtesy McEvoy Company, Houston, Texas.

TOUGH! . . . is the word for the McEvoy Fluid Weight Intermitter with its heart of neoprene!

The intermitter is an ingenious piece of oil field equipment which lifts fluid by gas. The whole operation depends upon the ability of the neoprene diaphragm "to take it." It is the flexing of this diaphragm that keeps the oil moving through tubing just as the flexing of the human heart keeps blood moving through the veins. The diaphragm flexes to close the valve when the tubing string is empty. It flexes to open the valve when the fluid column in the tubing reaches the height of the fluid column in the oil tube. If the neoprene diaphragm wore out this gas lift system would quit. But because the neoprene is strong and durable and resists oil and gas, it didn't wear out!

This stress and strain is nothing for the neoprene diaphragm! In a recent durability test, under conditions more adverse than those found in the well, it was flexed in kerosene 170 times a minute for nearly 82 days —a total of 20,000,000 flexes! And although the testing machine failed, the diaphragm was none the worse for wear!

McEvoy Company is one of hundreds of manufacturers that are relying on the remarkable qualities of this Du Pont synthetic rubber to do an important job at vital points in industry. Neoprene has the strength, resiliency and toughness of natural rubber . . . but it is far more resistant to oils, gasoline, corrosive acids and gases. Yes, neoprene has so thoroughly and ably "dug in" to industry that some equipment would actually have to be redesigned to carry on without it! For information, write E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Div., Wilmington, Del.

START NOW TO DEVELOP NEW THINGS FROM NEOPRENE

Start your testing program today! It takes time and care to test and to evaluate a new product—if you begin now, you will be prepared for the future.

Of course, neoprene is still on priority. But if you consult your regular supplier, you will probably be able to obtain a sufficient quantity for development work. Larger quantities will soon be available. Our Deepwater Plant in New Jersey is now producing 1,300,000 pounds a month. By this time next year the output, including the new Louisville Plant, should be more than tripled. So start testing now and be ready to apply your results when these larger quantities become commercially available!

DU PONT
NEOPRENE
America's No. 1 Synthetic Rubber

Write for these two publications:

The Neoprene Notebook carries up-to-date information on new uses for neoprene. Ask to get on the mailing list.

The Neoprene Handbook contains background and interesting data on neoprene and its many uses.

Also available, for a loan, free of charge, is the new 20-minute sound movie, "The Story of Neoprene."

"...your new TRI CLAD REG. U.S. PAT. OFF. motor lives up to its name!"

WRITES RUSSELL S. EGGLESTON, SUPT. AMERICAN ALLSAFE COMPANY, BUFFALO, N. Y.

PROBABLY it's only natural that a manufacturer of safety equipment should put emphasis on protection features of electric motors when he is choosing them for use with new plant equipment. Here is the case of such a manufacturer who not only *sought* those features but *got them*—he selected Tri-Clad motors. Mr. Eggleston reports in his letter below:

AMERICAN ALLSAFE COMPANY INC.

INDUSTRIAL SAFETY AND FIRE PROTECTION EQUIPMENT — Allsafe PRODUCTS — THE BEST SAFETY EQUIPMENT IS THE CHEAPEST INSURANCE

1245 NIAGARA STREET • BUFFALO, NEW YORK

August 12, 1941

Mr. E. O. Jones
General Electric Company
1 W. Genesee Street
Buffalo, New York

Dear Mr. Jones:

Continued production of safety equipment is of paramount importance in conserving man power for defense. Consequently, when we recently moved to our new plant we decided to replace our old motor drives.

happy to inform you that our decision was well justified, for in operation and appearance these motors are more than satisfactory. The protection feature is a big help in our machine shop where there is danger of falling material.

We thought you would be interested in knowing how your new Tri-Clad motor lives up to its name. When we are in the market for more motors, we shall certainly specify Tri-Clad.

Yours very truly,
Russell S. Eggleston
Supt.
AMERICAN ALLSAFE COMPANY

Using new materials in better ways, General Electric builds the Tri-Clad motor to meet the many adverse operating conditions commonly found in industry. They are specifically designed to give *extra protection* against (1) physical damage; (2) electrical breakdown; and (3) operating wear and tear. Ask your G-E representative for full information on types and sizes now available. *General Electric, Schenectady, N. Y.*

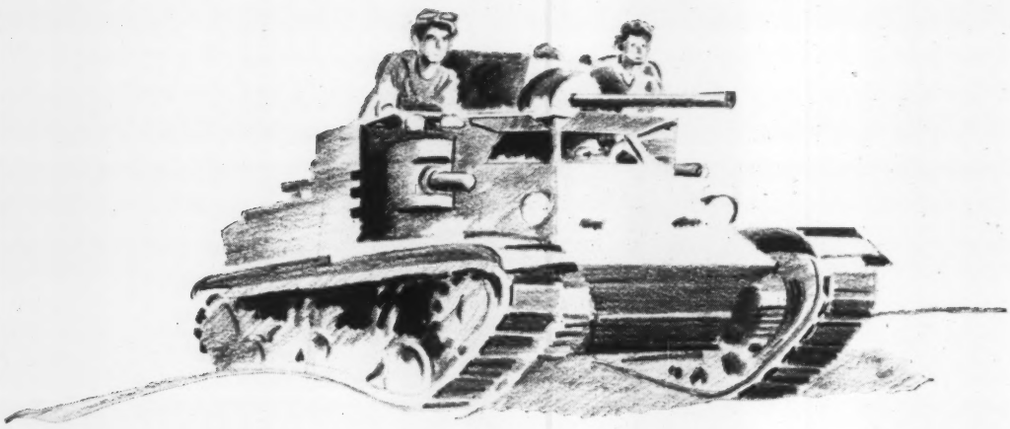
BUILT FOR PROTECTION FIRST.....TO LAST

GENERAL ELECTRIC

750-97-8858

Nothing's too good

for our $21-a-month men—



Trucks, tanks, guns, searchlights, instruments—all the paraphernalia of war—must be accurate, durable, dependable. Military standards are as tough as they come—*must be*, for failure could be disastrous. Meeting defense deadlines is no cinch—here, it takes:

* *A Production Line* for shipment of springs in large or small quantities to meet *your* production line requirements.
* *A Production Line* of heat-treating equipment, batch type and continuous, with carefully controlled atmospheres.
* *A Production Mill* producing unexcelled cold-rolled spring steel.
* *Time-trained craftsmen*...whose life calling is springmaking.

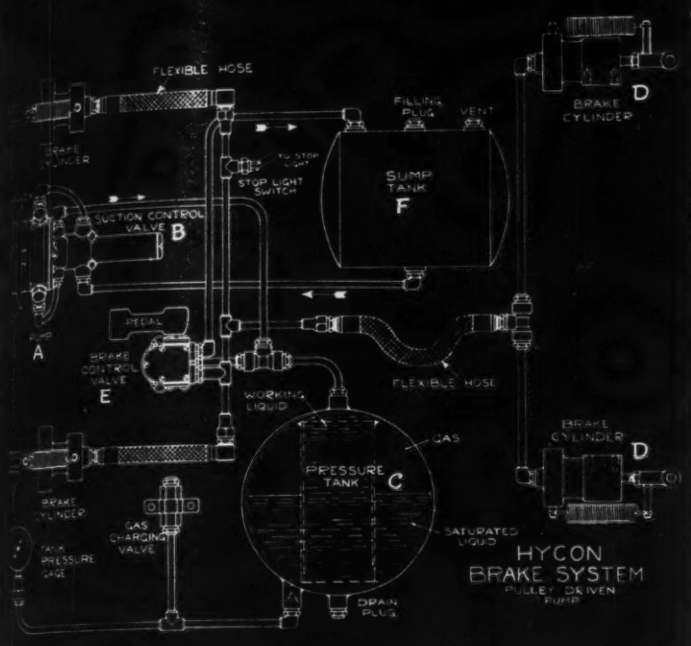
For American Products

Barnes-made Springs

and Spring Steel

WALLACE BARNES CO., BRISTOL, CONN., U.S.A.

DIVISION OF ASSOCIATED SPRING CORPORATION



Typical installation with Hycon pump and pressure tank actuating 4 work cylinders

e diagram shows a typical assembly of HYCON equipment. The k cylinders (D) may serve any desired function such as the move- t of a brake, clutch lever, door, electric circuit breaker. To these, raulic pressure is applied in any amount up to the designated t by the control valve (E). The energy for actuating the work cyl- ers is primarily derived from the pressure tank (C) and this in is charged by the pump (A). The delivery from the pump is gov- ed by the suction control valve (B). The work cylinders on the rn stroke discharge into the sump tank (F) from which the fluid umped into the pressure tank and/or the work line.

HYCON

lends itself to many uses— here are just a few

con operates the steering and braking mechanisms of heavy vehi- including road, marine, air transport and track-laying tanks. It ulates speed and pressure in straight-line-movement mechanisms h as machine tools, processing and printing machinery, foundry mill apparatus, and doors of all kinds . . . replaces electric sole- ds and low pressure compressed air engines . . . tests high pres- e hose, lines and hydraulic devices . . . and provides for high ssure lubrication of thrust bearings and the support of heavy loads.

An invitation to engineers and executives

ore you next design the control or control-actuating system of any chanism employing straight line motion, get the facts on Hycon. ycon can probably help you to achieve new operating efficien- s, new compactness of design, new accuracy of control, and reased machine capacity at lower costs.

Many of the reasons why are implicit in the booklet recently pre- ed by Hycon and entitled, "Recent Developments in Systems for draulic Control of Straight Line Motion". A copy is being held for . Please let us know where to send it.

What are you looking for in control and control-actuating mechanisms?

PERFORMANCE?

Hycon gives you pressures up to 3000 psi in so controllable a form that you can literally split a drop of working fluid under several thousand pounds. Moreover, Hycon is always ready for action, intermittent or continuous . . . ready with power drafts far in excess of the pump's capacity and independent of its operation—and with a supply of power for you to tap when the prime power source fails.

ECONOMY?

Hycon is light, compact, and economical in cost. It eliminates the need for constant pumping on applications requiring intermittent operation and, within its working range, provides one of the highest ratios of power output to power input known in practical hydraulics. On one typical installation for example (the operation of a traffic fin) as much as 100 hp is supplied for fifteen seconds by the Hycon pressure storage tank and is replaced in 25 minutes by a 1 hp motor operating in connection with a Hycon pump.

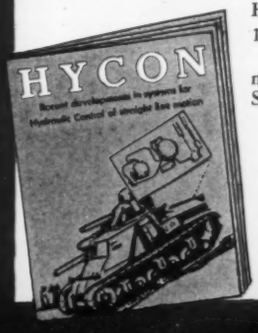
DEPENDABILITY?

Hycon operates efficiently and without adjustment under all ordinary temperature conditions . . . is designed to eliminate such trouble breeders as gaskets, stuffing boxes and packing, non-metallic diaphragms and pipe threads...and operates so all moving parts are submerged in lubricant, and rubbing surfaces are hardened by nitriding or equivalent process.

HYDRAULIC CONTROLS, INC.

Division of The New York Air Brake Company

Dept. 106, 122 South Michigan Avenue, Chicago, Ill.



Hydraulic Controls, Inc., Dept. 106
122 South Michigan Avenue, Chicago, Ill.

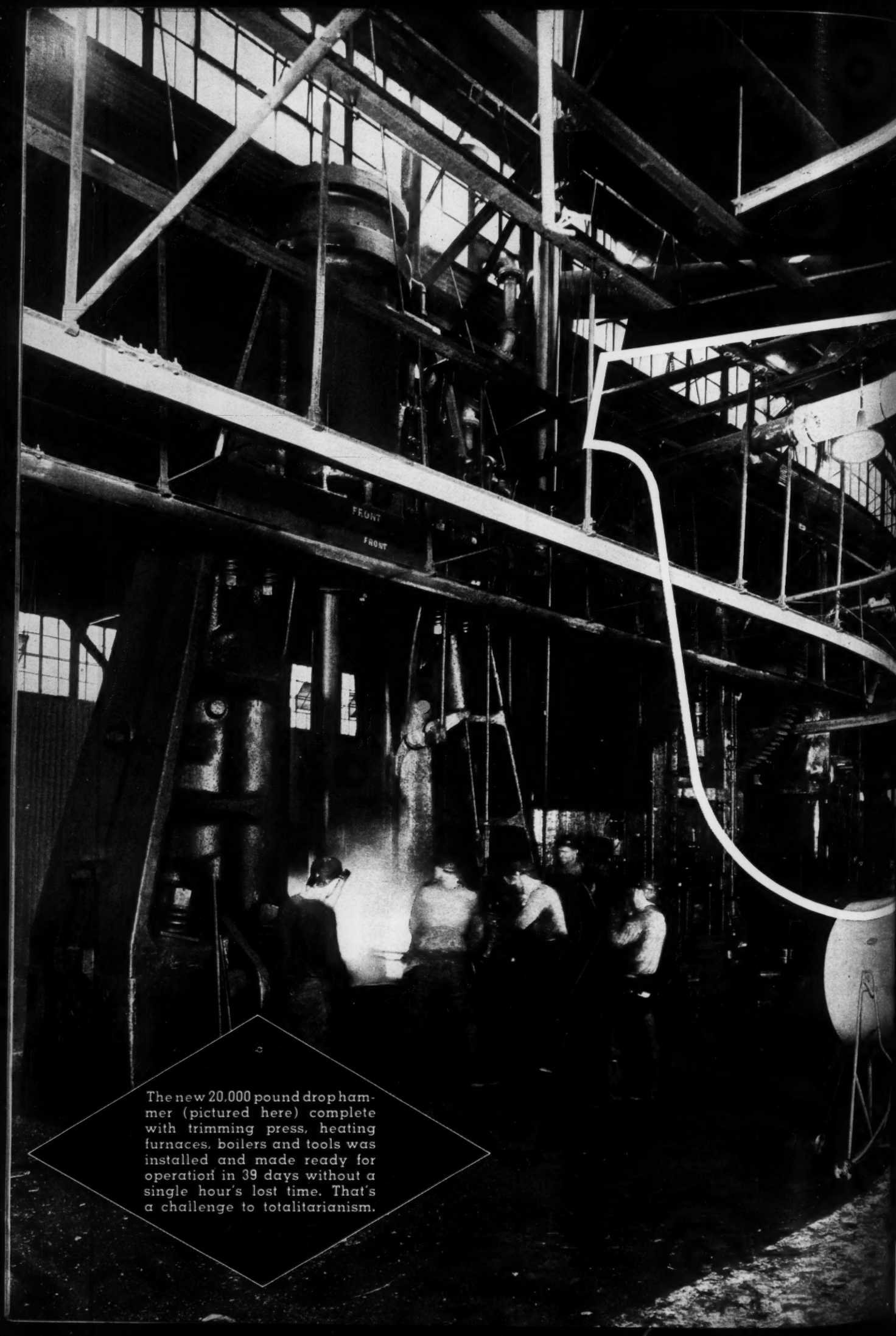
Please send me my copy of "Recent Developments in Systems for Hydraulic Control of Straight Line Motion" to:

Name.....

Company.....

Street Address.....

City.....*State*.....



The new 20,000 pound drop hammer (pictured here) complete with trimming press, heating furnaces, boilers and tools was installed and made ready for operation in 39 days without a single hour's lost time. That's a challenge to totalitarianism.

A Report on Progress—

About the end of 1940 our expansion program involving the expenditure of over $1,500,000 was completed with the addition of a 20,000 pound drop hammer, three steam hammers, several upsetters, several heat treating furnaces and a new fully equipped machine shop. At that time, our new production program on national defense forgings was well under way.

By June of 1941 our production of upset, drop and steam hammer forgings was nearly trebled. Direct and indirect defense forgings accounted for over 92% of our output. Forged parts for tanks, gun mounts, fighting planes, locomotives, diesel engines and ships were leaving our shops in an unending stream. Our number of employees during this period has more than doubled.

This, then, is our report to industry—industry we have so long served and hope soon to serve again with our entire facilities.

KROPP FORGE COMPANY

World's Largest Job Forging Shop

5301 W. Roosevelt Road, Chicago, Illinois

Representatives in Principal Cities

SERVING INDUSTRY 18 SINCE 37

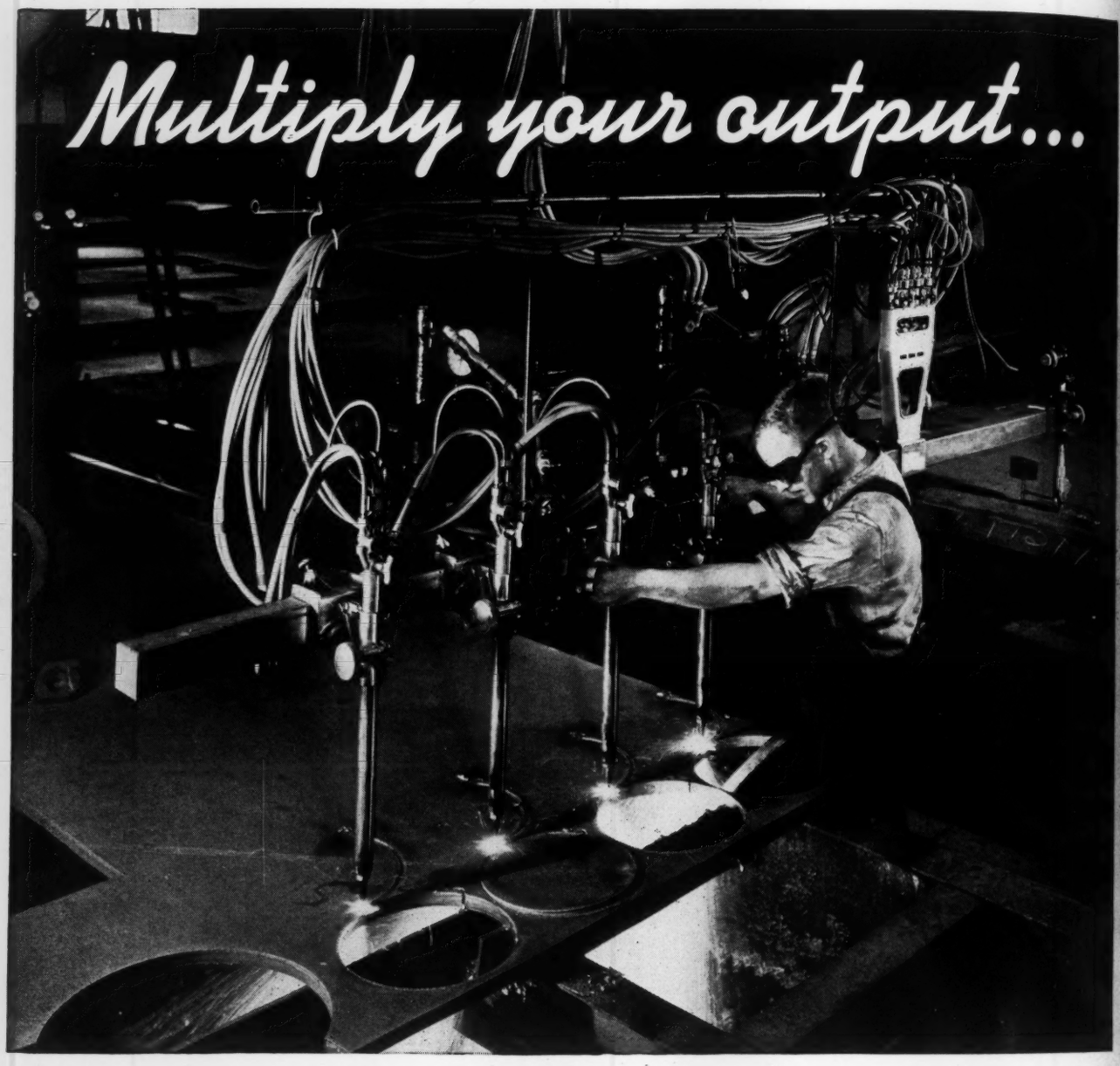
K

KROPP FORGE CO.

OVER 100 YEARS

KROPP

Multiply your output...



...USE AIRCO MULTIPLE GAS CUTTING

The modern way to meet the pressure of today's production needs—an Airco Travograph with a multiple torch hook-up, cutting several parts from steel plate simultaneously. Here, the Chicago steel warehouse of A. M. Castle is using this Airco machine to cut out 4 gear blanks at one time, quickly, accurately, and at low cost.

When quantities of parts are required—whether large or small—there's an Airco gas cutting machine to do your job. The practical assistance given by members of our Applied Engineering Department assures customers of the most economical results from Airco Gas Cutting Machines. Write for full details.

Air Reduction

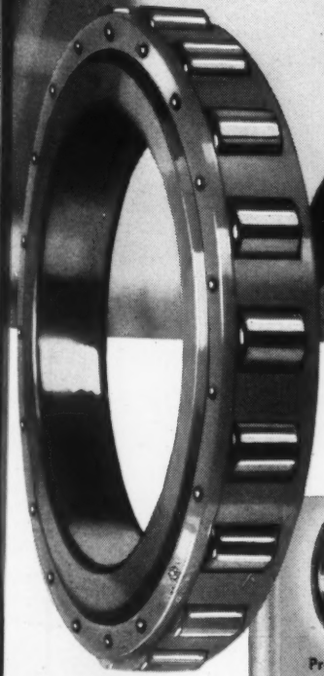
General Offices: **60 EAST 42nd ST., NEW YORK, N. Y.**

IN TEXAS
MAGNOLIA-AIRCO GAS PRODUCTS CO.
AIRCO DISTRICT OFFICES IN PRINCIPAL CITIES

AIRCO — WILSON

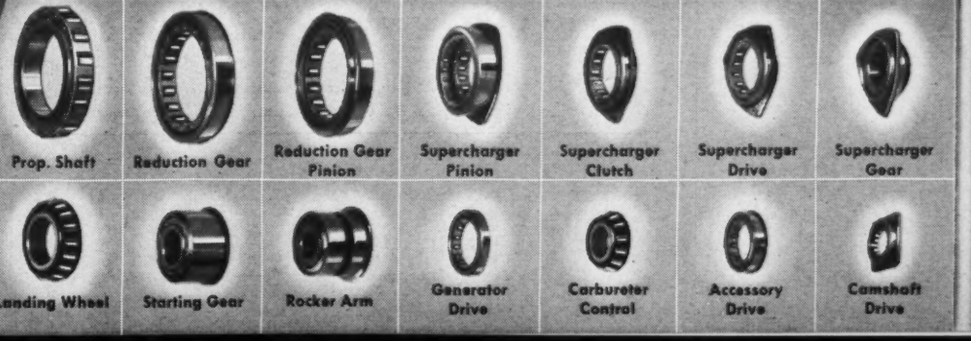
Anything and Everything for **GAS WELDING or CUTTING and ARC WELDING**

Keep 'em Flying



Propeller Shaft

BOWER
ROLLER BEARING CO.
Detroit, Michigan



Ask for it...

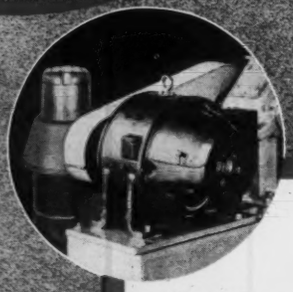
An interesting full color, 4-page folder featuring Bower advantages to national defense.

FOR FACTORIES WITH A-C. POWER..
A NEW PRODUCTION AID

AN ALL-ELECTRIC ADJUSTABLE-SPEED DRIVE for A-C. CIRCUITS

Speed Ranges up to 16 to 1
Sizes 1 to 30 hp.

RELIANCE V*S DRIVE

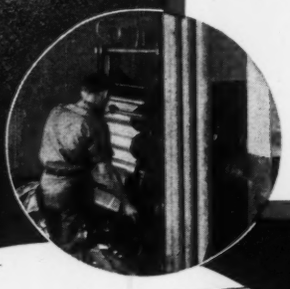


POWER

Plenty of it, applied directly without intermediate speed-changing devices.

SAFE SPEEDS FOR THREADING AND INCHING

The drive can be arranged to give very slow speeds while threading material by hand or setting up work.



SPEED CHANGES

Smooth changes over ranges up to 16 to 1. Wider ranges under special conditions . . . Speeds can be adjusted while machine is in operation.

QUICK STOPPING

Obtained electrically either by operation of speed adjuster handle or *stop* button.

CONTROLLED ACCELERATION

Torque is provided to suit the job. No clutches are needed. Acceleration is smooth so that driven machine and material in process are not subjected to undue shock or strain.

SPEED SETTING

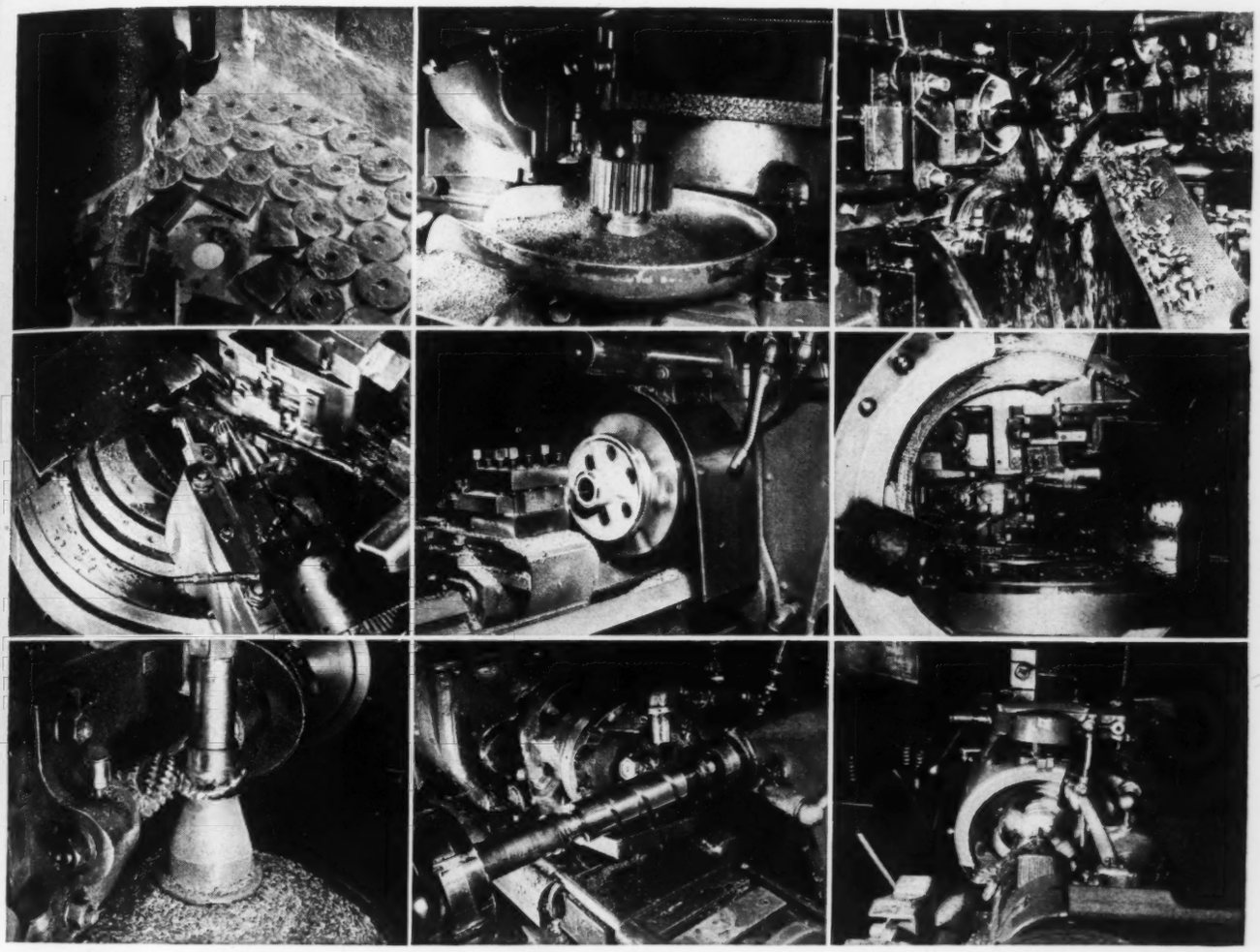
When set for a given operation the motor may be stopped and started without interfering with the speed setting.

All within Easy Reach

The Reliance V*S Drive ... convenience without ... changes and stops ... added anywhere that ...

RELIANCE ELECTRIC & ENGINEERING COMPANY
1088 Ivanhoe Road • Cleveland, Ohio
Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville, S. C. • Houston, Tex. • Los Angeles • Plainfield
New York • Philadelphia • Pittsburgh • Portland, Ore. • St. Louis • San Francisco • Syracuse, N. Y. • and other principal cities

RELIANCE A-C D-C MOTORS



FULL SPEED PRODUCTION!

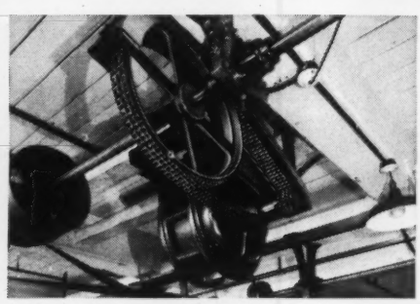
To assist you in maintaining "full speed production" as required by the National Defense Program, we suggest you incorporate our line of Standardized Stock Power Transmission Equipment in your product. Our complete line consists of over five thousand types and sizes of standardized gears, chain drives, speed reducers, couplings, ball bearings and other miscellaneous power transmission accessories and, what is vitally important, we are "all tooled up" for the production of these universally accepted products.

General catalog No. 53 contains complete specifications and list prices of our entire line of power transmission equipment; send for a copy and fit "BOSTON GEARS" into your contribution to National Defense.

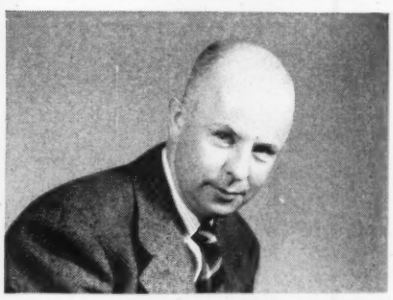
BOSTON GEAR WORKS, INC. NORTH QUINCY, MASSACHUSETTS

NO BETTER REASON FOR USING REX ROLLER CHAIN BELTS!

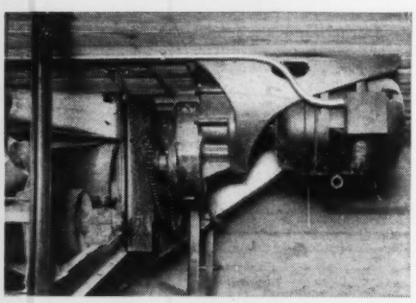
① **"WHAT DO YOU MEAN?"** asked this chief designer. "Why should your roller chain belts last longer than others? They don't cost more and don't look any different. What's the reason, if any?"



② **"YES," I SAID, "THEY ARE** similar in appearance and in price. But, in design, in lubrication methods, in wearing qualities and in background Rex roller chain belts are in a class by themselves!



③ **"THAT'S WHY FOR SO MANY MACHINES** Rex roller chain belts are first choice—they last far longer. They postpone replacement worries and eliminate a lot of delays formerly due to breakdowns.



④ **"WE MAKE ALL SIZES AND TYPES—** over 2000, to put it in round numbers. We can give you the *proper* chain belt for your job, whether it's for power at low speed or efficiency at high speed!"

⑤ **"THAT'S LOGICAL,"** he said, "and I never thought of it. You don't have to solve every problem with one chain belt. Where's the whole story on your line?—I'd like to investigate when I get time."

⑥ **"RIGHT HERE IN OUR NO. 444 CATALOG** —768 pages of data on every type of chain belt you'll ever need. Use it when designing your drives and conveyors and you'll never go wrong."

P.S. *Before* you *buy any chain belt for use on new or existing drives and conveyors, sena for Catalog No. 444 mentioned in this imaginary conversation. Then we believe you'll want to see the Rex Man. Address, 1643 W. Bruce Street, Milwaukee, Wisconsin.*

REX CHAIN BELTS

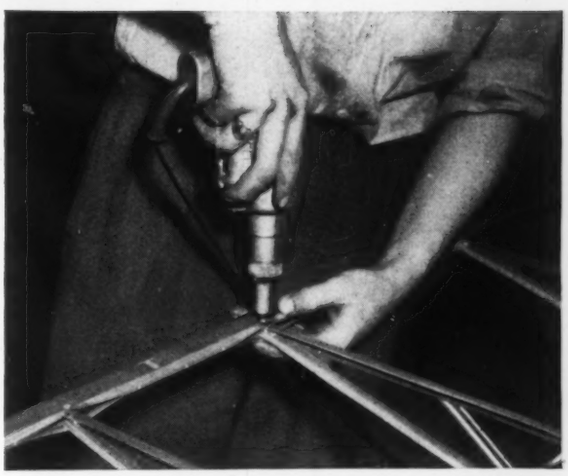
CHAIN BELT COMPANY OF MILWAUKEE

Baldwin-Duckworth Chain Belt Division, Springfield, Massachusetts • Worcester, Massachusetts
Rex Chain Belt and Conveyor Divisions, Milwaukee, Wisconsin

50TH ANNIVERSARY 1891 REX 1941 CHAIN BELT COMPANY

Can YOU stretch a work-week to 8 days?

It HAS been done on many assembly jobs . . . A P-K Assembly Engineer may point the way for you!



TAYLORCRAFT SPEEDS ASSEMBLY *of planes for Civilian Pilot Training Program by using Parker-Kalon Self-tapping Screws for many applications. The assembly shown above is typical.*

Whether you make planes, tanks, bombers, or any of the thousands of other products for defense, or for essential civilian needs, in today's vital task of getting more assemblies per man-hour, a Parker-Kalon Assembly Engineer can be a big help! He can help you effect time-savings of 25 percent to 50 percent in the many assemblies suited to Parker-Kalon Quality-Controlled Self-Tapping Screws. Wherever the P-K Engineer uncovers a place to use this simpler method . . .

You gain time by eliminating tapping and all its problems . . . fumbling with bolts and nuts . . . riveting in hard-to-get-at-places. Just one simple operation makes fastenings in thin sheet metal or heavy steel, die castings or plastics!

You gain secure fastenings . . . actually stronger than fastenings made with machine screws in tapped holes, or with bolts and nuts and lock washers!

You cut out "slow-ups"! Every genuine Parker-Kalon Screw drives easily and holds tight. The unequalled Parker-Kalon Quality-Control Laboratory routine protects against "doubtful screws" . . . screws that look all right but some of which fail to work right.

CALL for a Parker-Kalon Assembly Engineer to go over your fastening problems. You'll quickly see why some of industry's largest plants regularly use this advisory service. Or send assembly details for recommendations and samples. Parker-Kalon Corporation, 192-200 Varick Street, New York.

The Screw Industry's Finest Quality-Control Facilities

PARKER-KALON

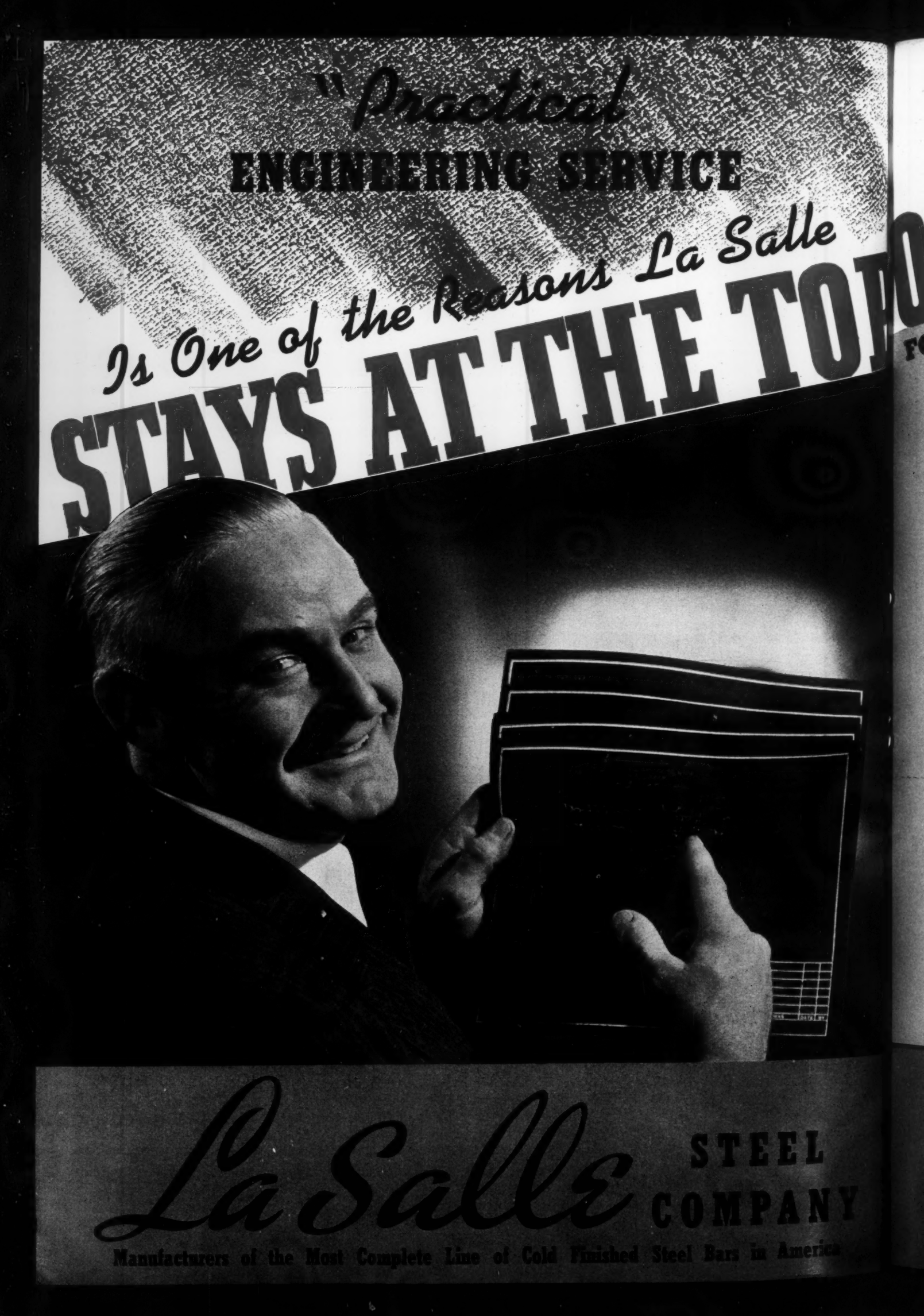
Quality-Controlled

SELF-TAPPING SCREWS

Give the Green Light • to Defense Assemblies

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY . . . AND OTHER FASTENING DEVICES

"Practical
ENGINEERING SERVICE
Is One of the Reasons La Salle
STAYS AT THE TOP



La Salle STEEL COMPANY
Manufacturers of the Most Complete Line of Cold Finished Steel Bars in America

"TOP OF OUR LIST"
FOR COLD FINISHED STEEL BARS

● The great production demands now being made on plants and shops make "practical engineering service" on cold finished steel bars extremely valuable. Such service, as developed and practiced by La Salle for many years, has meant many things:

It has meant going into a plant and helping the buyer determine the one right steel for every job.

It has meant working understandingly with machine tool operators to get more production out of present equipment.

It has meant going into a huddle over parts blue-prints to weed out obsolete steel bar grades and to recommend newer, more efficient analyses.

It has meant briefly, making available all the accumulated background and experience of years of working with cold finished steel bar users.

Such "practical engineering service" now is paying dividends in hundreds of plants where La Salle recommendations are helping management meet defense-quickened schedules. It is one of the many reasons why La Salle today stands high on purchasing agents' lists of suppliers. It explains one of the reasons why La Salle will *stay* at the top of the list for hundreds of cold finished steel bar users for years to come.

LA SALLE STEEL COMPANY · CHICAGO, ILLINOIS

★ ★ ★ ★ ★ ★ ★ ★ ★

As with the rest of the industry, La Salle's No. 1 job now is co-operating to the fullest possible extent in the Defense Program.

★ ★ ★ ★ ★ ★ ★ ★ ★

★ *Engineered Quality*
★ *Advanced Research*
★ *Practical Metallurgy*

La Salle STEEL

IN THE MIDWEST
IT'S *La Salle*

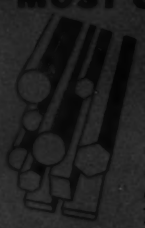
Reduction in Traffic Delay Through

CENTRAL LOCATION

An important factor in La Salle's acceptance as the "top" source of supply by many steel bar users is its central location. The La Salle plant at Hammond, Indiana is directly served by three railroads and a main trunk highway. This reduces to a minimum the possibilities of delay in shipments due to inadequate transportation facilities.

Time and Money Saved by

"MOST COMPLETE LINE"



The economy, convenience and safety of having a source that is equipped to give service on a complete line of products rather than on only a portion of a user's requirements is seldom overlooked by buyers of cold finished steel bars. La Salle produces "The Most Complete Line of Cold Finished Steel Bars in America."

Faster Production, Lower Costs Through

ADVANCED RESEARCH

Faster cutting, better, lower cost materials for steel users is the purpose of La Salle's research which never stops. Experienced metallurgists are unceasingly searching for new improved steels to add to those developed in the past: 1020-90, Silver Tip, Gold Tip, Tritex, Tuftork and STRESSPROOF. Another factor which makes La Salle "stay at the top of the list"!

Cash in on La Salle's

FORESIGHT

"Yesterday's Foresight Meets Today's Demands" is the basic policy of La Salle's continuous effort to serve users better and better. Expanded facilities, improved methods of operation and better and better steels are the result—results that pay dividends to users who think of La Salle as their main source of supply for cold finished steel bars.

Ask Anyone in Industry!

ALEMITE PROGRESSIVE SYSTEM LUBRICATES FILTERS POSITIVELY, CLEANLY, IN LESS TIME

SAYS MILWAUKEE SEWERAGE COMMISSION

WRITES Hans O. Wenzel, Assistant Superintendent for the Sewerage Commission of the City of Milwaukee, "After equipping our No. 13 Oliver Filter with your Progressive System, the results obtained . . . prompted us to equip the remaining twenty-three filters with this system.

"The amount of lubricant to each bearing was consistent, considerable time was saved, and in general the entire job of lubrication was clean."

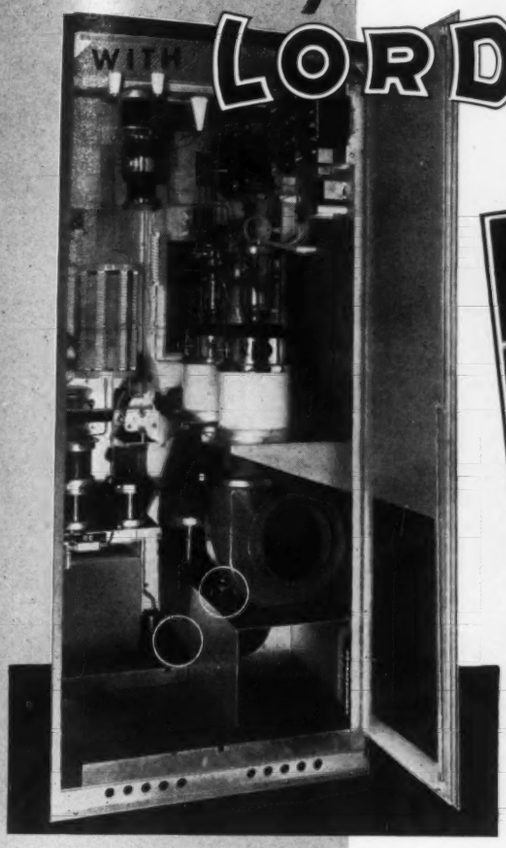
This modern centralized system steps up production in all types of industry by saving man-hours and machine-hours. All bearings are serviced from one location—given a predetermined quantity of grease *while machinery is in operation.* An automatic device signals operator when the job is done. Write for complete facts!

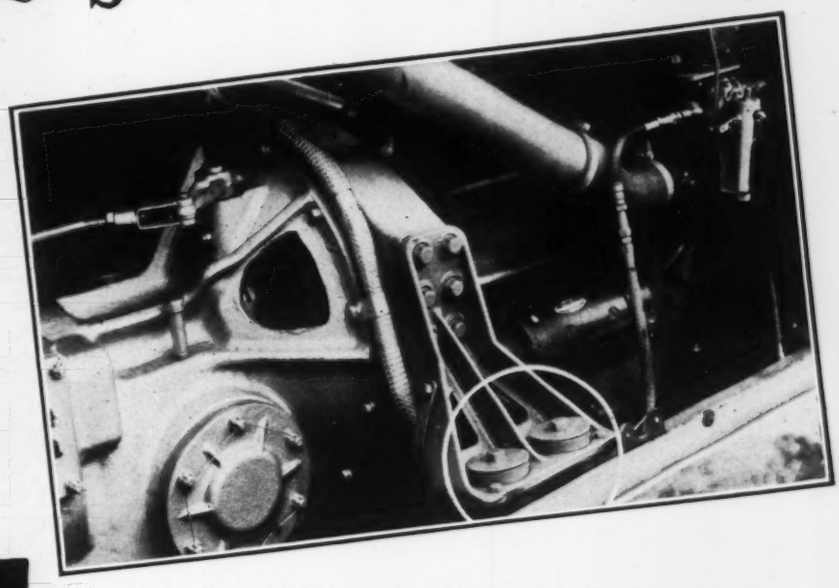
ALEMITE
REG U.S. PAT. OFF.
Industrial **LUBRICATION**
1804 Diversey Parkway, Chicago, Illinois • Belleville, Ontario

Another Product of STEWART WARNER

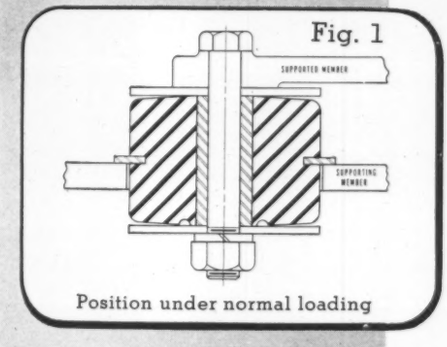
Two-Way Protection

WITH LORD VERTICAL SNUBBING MOUNTINGS

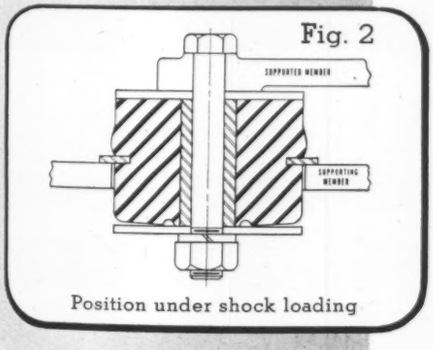




Above: Lord V.S. Mountings protect this Twin Coach bus engine against road shock and isolate the body from engine vibration. Left: In this radio installation Lord V.S. Mountings isolate the normal vibratory forces caused by the blowers and protect it against shock due to starting loads and possible operation at resonance.



Position under normal loading



Position under shock loading

❶ *Protect equipment against shock*
❷ *Isolate smaller vibratory forces*

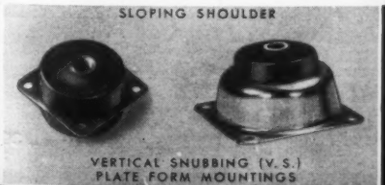
MANY types of mechanical equipment are subjected to sudden, heavy shock loads as well as normal vibratory forces. It is possible to isolate these two types of disturbances by the use of Lord Vertical Snubbing (V.S.) Bonded Rubber Mountings, illustrated below. These mountings will support loads from a few ounces up to 1150 pounds.

The design for this two-way protection is shown in the V.S. Plate Form Mounting cross-sections at the left. Figure 1 shows the mounting supporting its rated load and it is operating freely in sheer, isolating normal vibration. Figure 2 illustrates the action at the moment of shock. The metal washer has contacted the rubber snubbing shoulder and movement of the suspended member has been arrested. The reverse of shock, or rebound, will then occur and is arrested in a similar manner as shock, but in the opposite direction. Stability of the mounted assembly is characteristic of all Lord Mounting installations.

The vibration engineering experience of Lord Engineers, gained in practically every field, is available without obligation.

LORD MANUFACTURING COMPANY . . . ERIE, PA.

245 E. OLIVE AVE., BURBANK, CAL. 280 MADISON AVE., NEW YORK 844 N. RUSH ST., CHICAGO



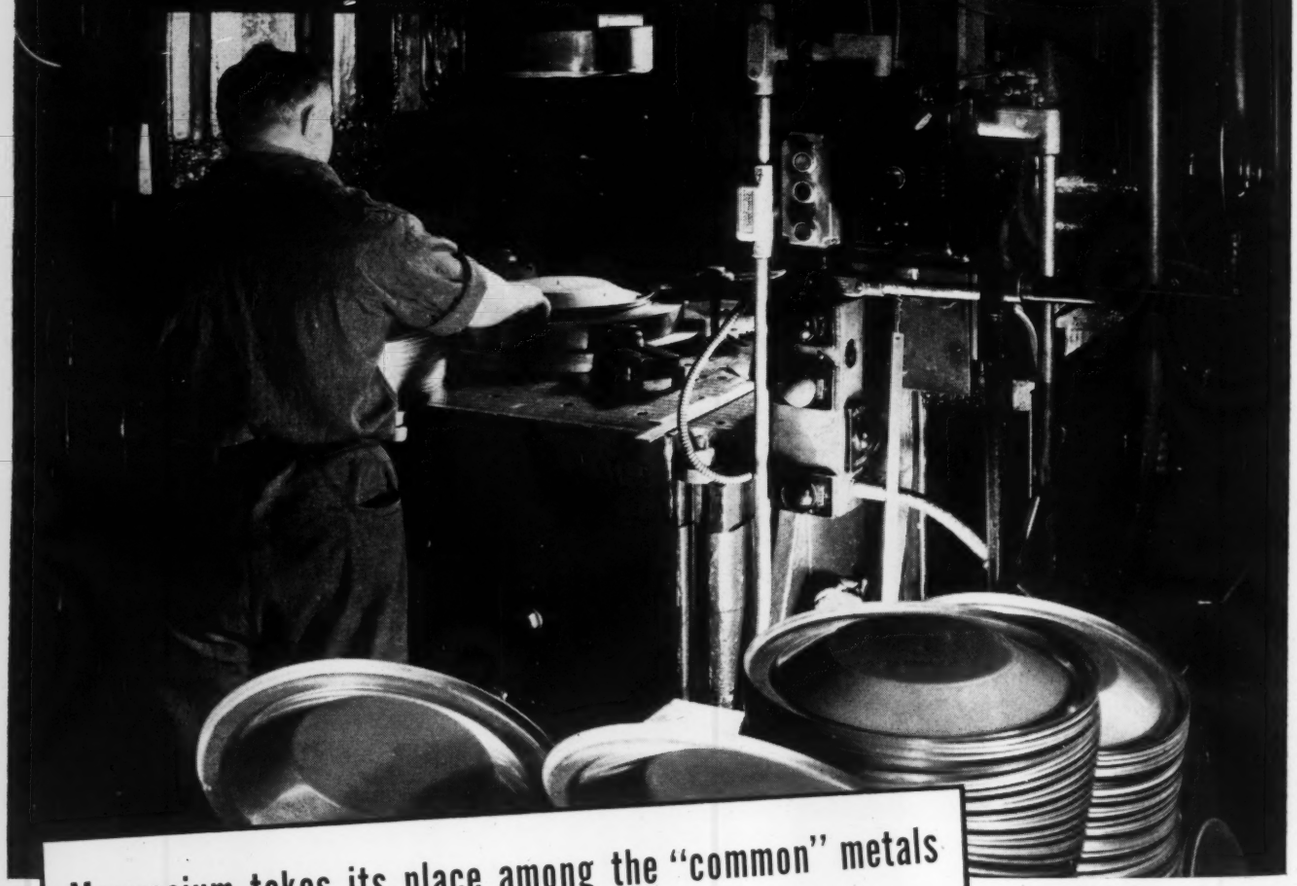
LORD
BONDED RUBBER
SHEAR TYPE
VIBRATION
MOUNTINGS

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

MAZLO

MAGNESIUM PRODUCTS

THE LAST WORD IN LIGHTNESS



Magnesium takes its place among the "common" metals

MAZLO factories are doing today what they've dreamed of doing for years. They're in mass production on many Magnesium Alloy products, fabricating and helping other manufacturers produce in tremendous quantities.

What fabricators are learning in this push for production will later profit every peacetime user of Mazlo Magnesium products. Improved manufacturing methods and reduced costs will increase the usefulness of Magnesium in every commercial form. Many new applications are indicated.

Magnesium has earned wide acceptance because of the unusual advantages it offers. As metal again becomes generally available for non-defense uses, consumers and manufacturers alike will be able to profit fully by using this lightest of lightweight metals in an ever widening circle of applications.

MAZLO

REG. U.S. PAT. OFF.

DEFENSE COMES FIRST

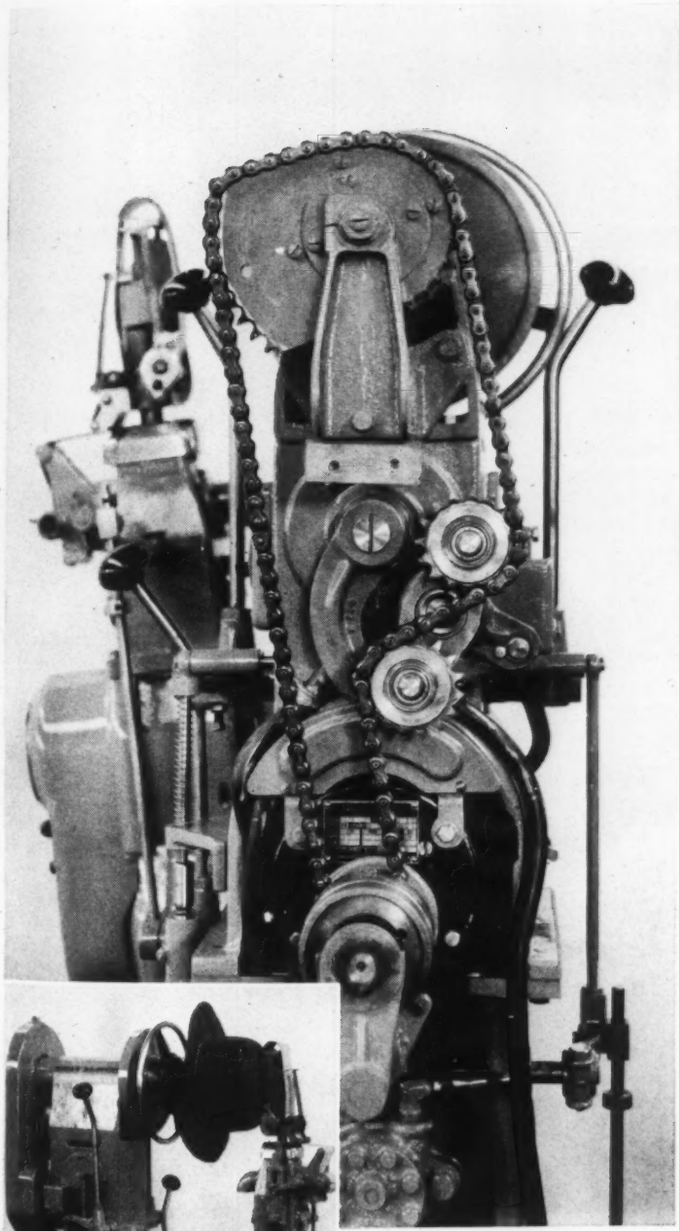
Magnesium, today, is "All Out for Defense." Civilian users have had to find substitutes. But we have not turned our backs. American Magnesium Corporation is increasing its fabricating facilities at a rate many times that required by normal peacetime markets. When the emergency is past, there will be an abundance of these lightweight products for all users. Sales Agent for Mazlo Magnesium products: Aluminum Company of America, 1703 Gulf Building, Pittsburgh, Pa.

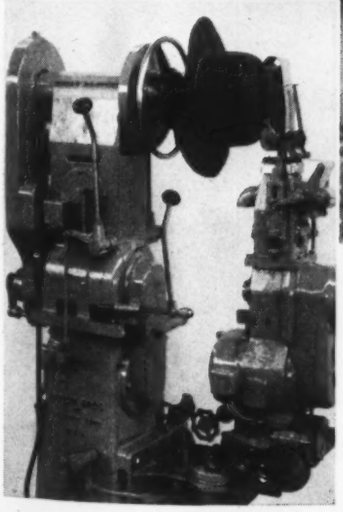
AMERICAN MAGNESIUM CORPORATION

Subsidiary of Aluminum Company of America

Hats Off TO DORAN BROS., INC.

Introducing the Odd-Shaped Sprocket





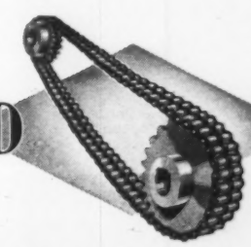
Hat finishing machine manufactured by Doran Bros., Inc., using Diamond Roller Chain Drives.

● Another illustration of ingenuity is the Doran Bros. hat crown finishing machine incorporating Diamond Roller Chain and the odd-shaped sprocket to achieve a desired result. This is an unusual case but serves to illustrate the versatility of chain drives.

By means of this bit of design, the surface velocity of the felt is held uniform throughout one revolution—and provision is made for two high and two low speed points to a revolution of the hat, with one high and one low speed revolution of the sprocket;—double speed variation for both sides of the hat.

The flexibility and adaptability of DIAMOND Roller Chain offers wide opportunity to the designing engineer—since it is available in pitch sizes from ¼ in. to 2½ in. —it may be run equally well on either side —it may be used for slow motions or high speed precision timing duties,—for main motor drives up to 1500 HP,—for shaft to shaft drives,—for short or long center drives of any kind.

The design and manufacture of roller chain has been the one and only job of Diamond Chain for over 50 years. Our engineering staff can help you solve your machinery and drive problems—and save your valuable time. We welcome your inquiry. DIAMOND CHAIN & MFG. CO., 435 Kentucky Avenue, Indianapolis, Indiana. Offices and Distributors in All Principal Cities.

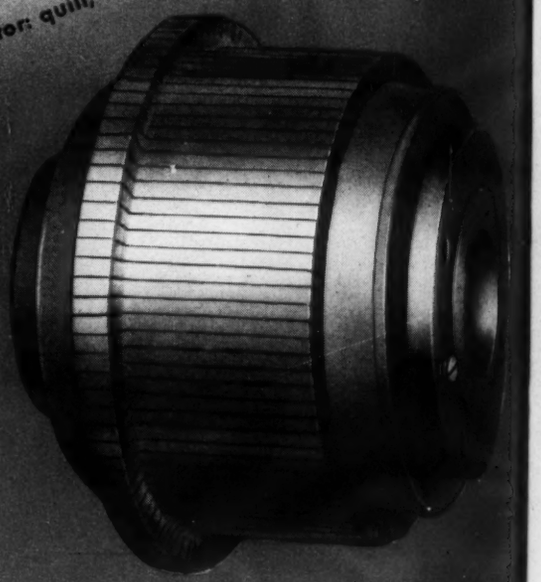


DIAMOND ROLLER CHAINS

Typical COMMUTATOR of the NEW G-E D-C MOTOR

WE ASSEMBLE IT WITH 12 TONS PRESSURE

Assembly parts of the new G-E direct-current motor commutator: quill, steel caps, mica cones, hardened-copper and mica segments, and retaining lock nut

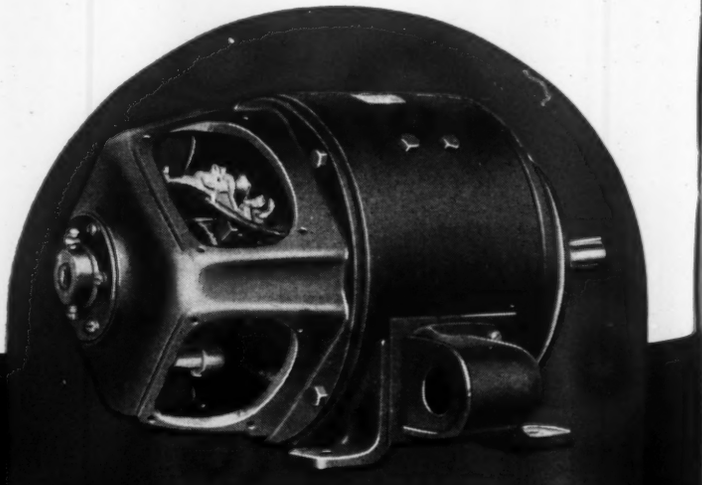


BUT YOU CAN TAKE IT APART —AND PUT IT TOGETHER— WITH A HAND WRENCH

YOU get good commutation in a G-E direct current motor because the great pressure and high temperature applied in assembling the commutator—plus careful machining — assure rigidity, uniformity, and precise alignment of every part. Yet, in an emergency, the entire commutator can be conveniently disassembled after removing a steel lock nut and set screw. Reassembling on the job requires no press.

You'll find other new features in this commutator: mica segments on the open end extend beyond the copper segments to give increased creepage paths; a tumbling process completely eliminates burrs from the hard-drawn copper segments; and the end of the assembly has a smooth, arc-resistant surface of Glyptal No. 1201 Red.

But features of the General Electric d-c motor are by no means limited to the commutator. Get the facts on the tough armature; sturdy, adjustable brush rigging; Formex wire field coils; and improved bearings. Call or write your local G-E office for details that show why you can expect economical, dependable service from this motor. General Electric, Schenectady, N. Y.



General Electric d-c motor, Type B, typical of the smaller ratings

GENERAL ELECTRIC

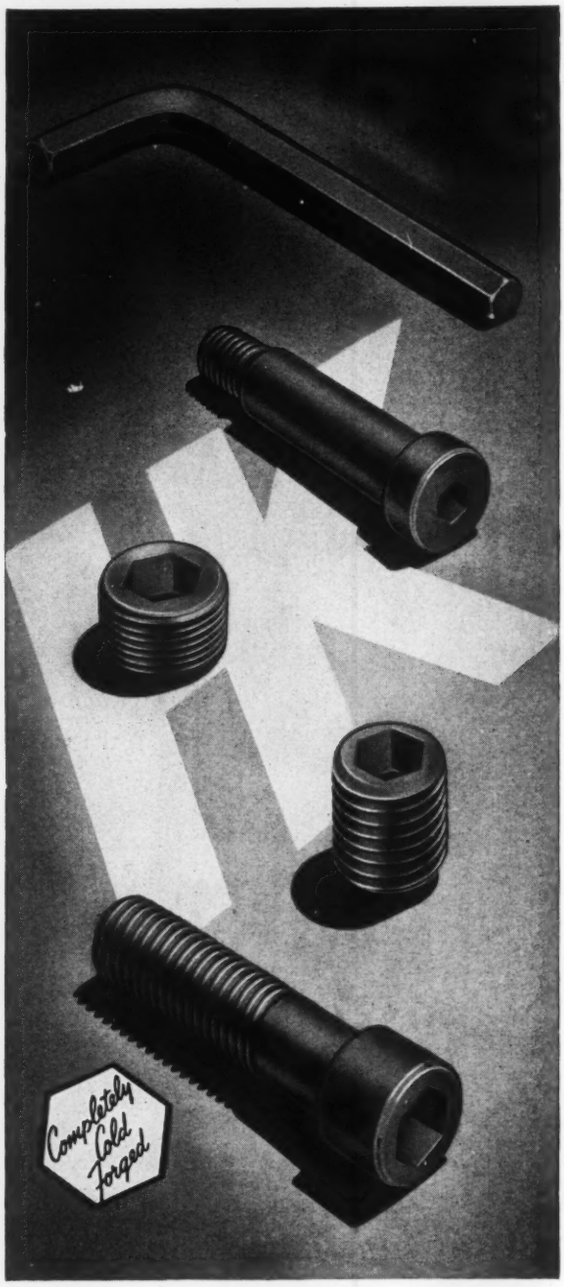
250-68-B 9M

While you're answering the appeal to "give us tools", give everything that ought to go with them. Into every machine you design and ship for defense production, at home or abroad, build the proper Veeder-Root Counting Device that will help users to get the utmost in quantity and quality of output. And no matter what type of machine you build, there are mechanical and electrical Veeder-Root Counters to provide a running report on production . . . show where adjustments can be made, time saved and quality improved. So be sure to give *complete* tools, equipped to make every stroke of work count to the utmost. And on any such priority work, we are ready to help you *now*.

VEEDER-ROOT
INCORPORATED
Hartford, Connecticut, U. S. A.

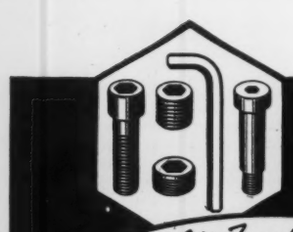
OFFICES IN: Boston, Chicago, Cincinnati, Cleveland, Detroit, Greenville, S. C., Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Montreal, Buenos Aires, Mexico City, London, Paris, Tokio, Shanghai, Melbourne.
In England: Veeder-Root Ltd., Croydon, Surrey
In Canada: Veeder-Root, Canada, Ltd., Montreal

SERVING THE NATIONAL DEFENSE PROGRAM



PRECISION MADE...—

GUARANTEED Unfailing PERFORMANCE



HOLO-KROME
TRADE MARK
fibro forged **SOCKET SCREWS**
THE HOLO-KROME SCREW CORP. HARTFORD, CONN., U.S.A.

Do You Want to Build A Better Product? Do You Want to Reduce Your Costs?

In this age of manufacturing, industry is constantly on the hunt for better, lighter, stronger, cheaper or more accessible materials.

Steel Castings are meeting these requirements —more of them every day.

In many industries, steel castings are proving to be the most economical and practical way to secure the unquestioned advantages of steel.

STEEL CASTINGS

Bring You These 7 Advantages

1 *Uniform Structure* for strength and shock resistance.

2 *Metal distributed* for strength with minimum weight.

3 *Wide* range of physical properties.

4 *Good Machining qualities* — lower finishing costs, better appearance.

5 *High rigidity,* accurate alignment, minimum deflection, better fit.

6 *Readily weldable* in composite structures.

7 *High fatigue resistance,* longer life, ideal for critically stressed parts.

For steel is an adaptable material. Its applications in industry cover the entire range of manufactured goods, and the machines which make them.

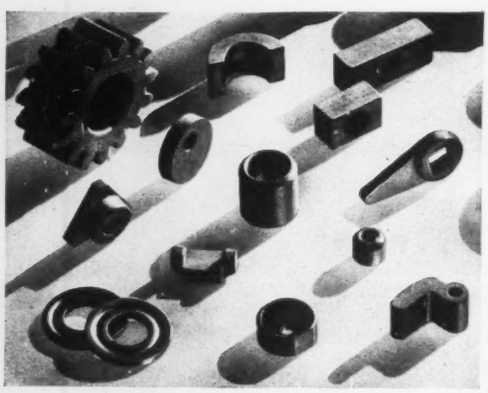
And because of the unusual technical cooperation within the Steel Castings industry, there is a constant free exchange of ideas and experience. Secrets have been shared. Technique has been constantly improved.

As the direct result of this enlightened working together as an industry, new designs and new methods have been perfected, to improve *your* product and reduce *your* costs.

To secure the benefit of the knowledge and experience which is aiding so many manufacturers, you have only to consult your local foundry, or write to Steel Founders' Society, 920 Midland Bldg., Cleveland. Please feel free to call upon our industry—there is no obligation.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS



● A few Durex Iron parts, made by compressing metal powders in dies, then heating under precise control of temperature and atmosphere. Many costly and time-consuming machining operations are avoided, and scrap loss is eliminated.

● Many parts produced by casting and machining or die cast from materials now hard to obtain, can be made readily and economically from iron powders. The Durex Iron Cam shown above is one of many parts engineered by Moraine from metal powders to provide new combinations of physical properties, new designs, and production economies.

What can Durex Iron parts do for you? Depending on the application they may replace parts made from vital materials . . . do an equivalent or better job for less money . . . simplify designs . . . speed up assembly operations . . . extend the life of moving parts through self-lubrication . . . release hard-pressed machines for the production of parts by other methods.

Check Durex Iron as applied to your specific requirements. Write today for Form 102-D, a valuable, factful bulletin on Durex Iron parts and applications.

MORAINE

Pioneer in Powder Metallurgy

MORAINE PRODUCTS DIVISION, GENERAL MOTORS CORPORATION, DAYTON, OHIO

NOW WE GET PEAK PROTECTION ALL THE TIME BECAUSE WE ELIMINATED

HAPHAZARD FILTER CLEANING

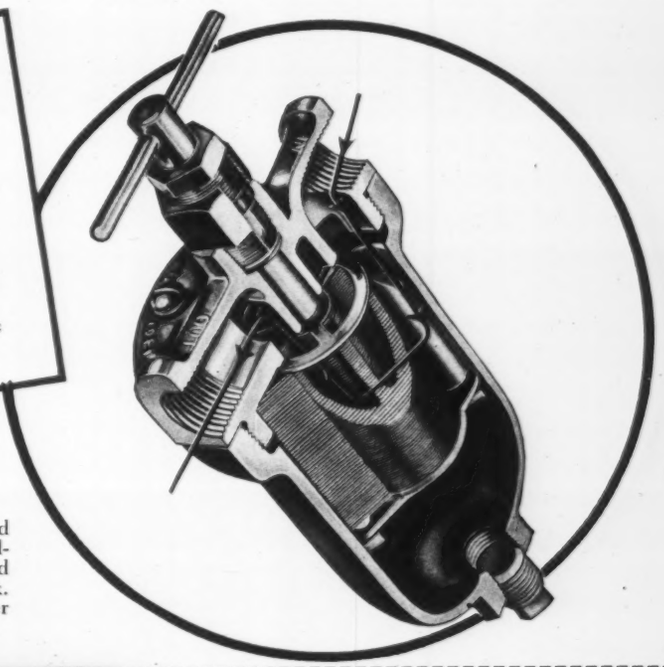
"There was always the danger of dirty fluid injuring moving parts due to someone forgetting to clean or replace a filter element at the proper time. Now — we insure peak protection all the time because Cuno Auto-Klean Filters are cleanable, automatically, while in operation."

No filter elements to be replaced, either, when you keep fluids on "GO" with Cuno! A turn of a handle — manually or mechanically — removes accumulated solids without interrupting fluid flow. Simple and sturdy, Cuno Filters keep at work *continuously* wherever fluids, air or gases are strained or cleaned. Call on Cuno Engineering for recommendations.

The free booklet, "80 Ways to Make More Money," gives examples of *continuously-cleanable* Cunos in a variety of applications. Send the coupon today.

Here Is a Small, Compact Unit You Can Conveniently Design into Your Machine

1 Substantial reduction in weight and space.
2 Efficient fluid cleaning with practically no pressure loss.
3 All-metal construction, non-collapsible filter element means long life.
4 Furnished in any construction, any machinable metal — to handle fluid, air, gas.
5 Internal or external mounting — no need of duplex installation.
6 Completely automatic filtration obtainable with Cuno Hydraulic motor.



Rubber Tube Clears Its Throat with Cuno Filter

A coal breaking unit employing hydraulic oil forced through a metal-reinforced rubber tube under expanding pressure encountered trouble when disintegrated rubber particles discharged into the oil storage tank. Pump, valves, etc., are now protected by a Cuno Filter installed between storage tank and pump.

KEEP FLOW ON "GO" WITH

CUNO

NO STOPS FOR CLEANING FLUID . . .
NO STOPS FOR CLEANING FILTER

CUNO ENGINEERING CORPORATION
212 South Vine Street, Meriden, Conn.

Please send me, free, "80 Ways to Make More Money"

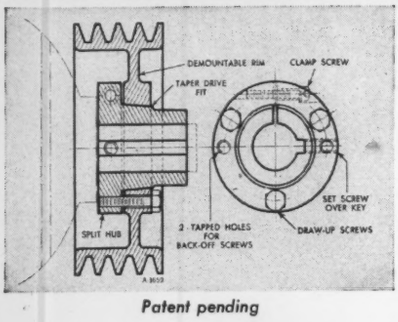
Name .....

Company .....

Street .....

City ..... State .....

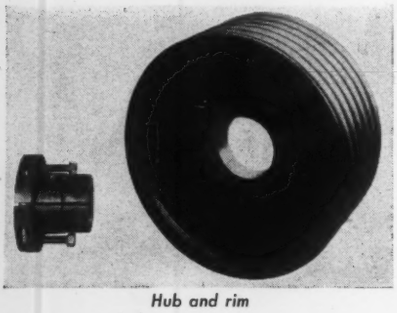
Speed up production with drive flexibility . . . by using WORTHINGTON Q-D SHEAVES They give you these 12 BIG PLUS $ VALUES and protection against breakdowns, at no extra cost.



Patent pending

BALANCED DESIGN

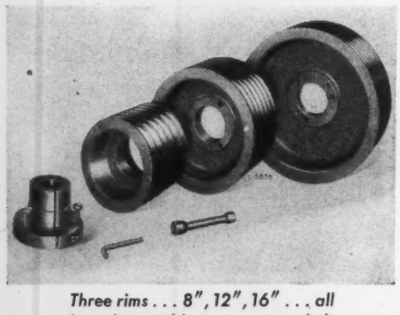
1. Overhang stresses reduced 25%.
2. All weave and wobble eliminated.
3. Reduction of bearing loads and shaft stresses on short stub-shaft applications.



Hub and rim

POSITIVE FIT ON SHAFT

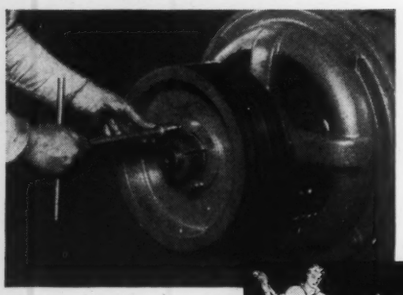
4. The equivalent of a press fit.
5. Perfect fit on undersize or oversize shafts.
6. Capacity to handle any shock loads.



Three rims . . . 8", 12", 16" . . . all interchangeable on same hub

QUICK DETACHABLE RIM

7. Seasonal speed changes made faster, safer, easier, cheaper.
8. Alignment always maintained . . . hub element remains intact on shaft.
9. No wearing parts to adjust . . . simple, fool-proof, trouble-proof.



Simple . . . quick

This method is obsolete. Eliminate it with Q-D Sheaves. →

QUICK DEMOUNTABLE SHEAVE

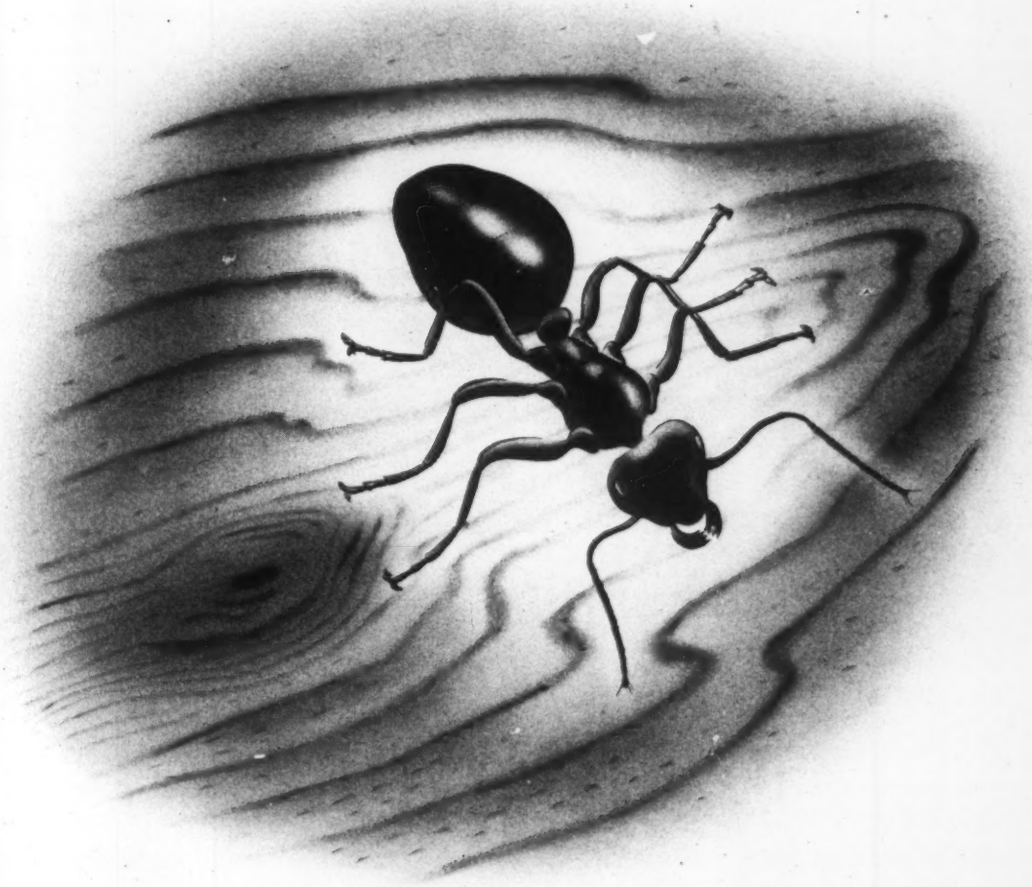
10. Maintenance greatly reduced.
11. No special tools required.
12. Off and on with a wrench in 60 seconds.

THE SHEAVE OF TOMORROW IS THE Q-D SHEAVE . . . made available to you TODAY. Write for booklet V-1400-B7 containing complete details, sizes available, and prices.

WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY
District Offices and Representatives in Principal Cities

MV1-1

WORTHINGTON



Ever hear an ANT walking?

Hoover Engineers have . . . they have developed a scientific Radio Device so sensitive that an ant's footsteps thunder like the beat of a horse's hoofs on a cobble-stone street. On this super-sensitive device every Hoover Bearing is tested for smoothness and quietness where bearing imperfections cannot escape detection. Hoover's unusually high standard of workmanship recognizes nothing short of near perfection. Is it any wonder that Hoover has won its place as . . . . The Aristocrat of Bearings?

HOOVER THE ARISTOCRAT OF BEARINGS

WITH HONED RACEWAYS . . . AN EXCLUSIVE HOOVER FEATURE

HOOVER BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN, U. S. A.

. . . for Army and Navy Parts

MADISON-KIPP hi-high PRESSURE

TRADE MARK REG. U.S. PAT. OFF.

ALUMINUM DIE CASTINGS

● We are handling orders for millions of die castings, difficult castings and vital parts for nearly all branches of U. S. defense and U. S. aid efforts. (Many of these parts were originated as die castings at Madison-Kipp). ● We will be pleased if we can be of assistance to you when you bid on Government contracts and also in furnishing die cast parts or assemblies after you have closed your deal. ● We can usually give price and delivery information by telephone because of having had over two years experience in developing special equipment and producing castings for Boosters, Fuzes, Bombs, Shot and other Ordnance parts. ● Just telephone Badger 7051, Madison, Wisconsin, and ask for the Ordnance Sales Department.

MADISON-KIPP CORPORATION
210 Waubesa Street, Madison, Wis., U. S. A.
Complete DIE CASTING SERVICE · FRESH OIL LUBRICATORS · HIGH SPEED AIR TOOLS

SUPPORTING 20 Tons, INSULATING

Against 8 Million Volts

The complex apparatus you see above is the new electrostatic generator at the University of Notre Dame. It is an atom smasher capable of developing eight million volts. It weighs twenty tons.

Obviously, the machinery to disintegrate nuclei by high speed electrons, depends upon hundreds of contributing factors for its successful operation. Each of these is vitally important to the process.

One of the materials in the generator, which performs a double duty well, is G-E Textolite laminated tubing. As a structural material, it is used to support the entire twenty-ton machine. As an electrical insulator, it withstands eight million volts.

The new generator is the second at Notre Dame to incorporate Textolite tubing. Although an unusual application, it is indicative of the many uses to which this material is being put for both mechanical and electrical purposes.

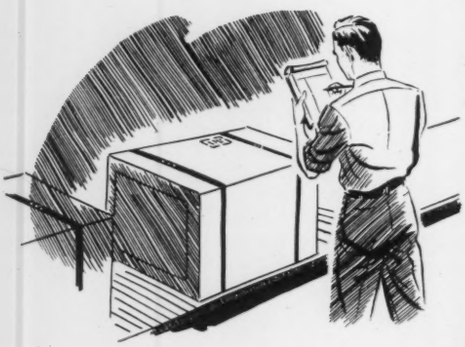
For the properties of this material and a thorough description of G-E Plastics Department's complete service, ask for a copy of our Textolite booklet. Write Section C-125, General Electric Co., 1 Plastics Ave., Pittsfield, Mass. PD-159

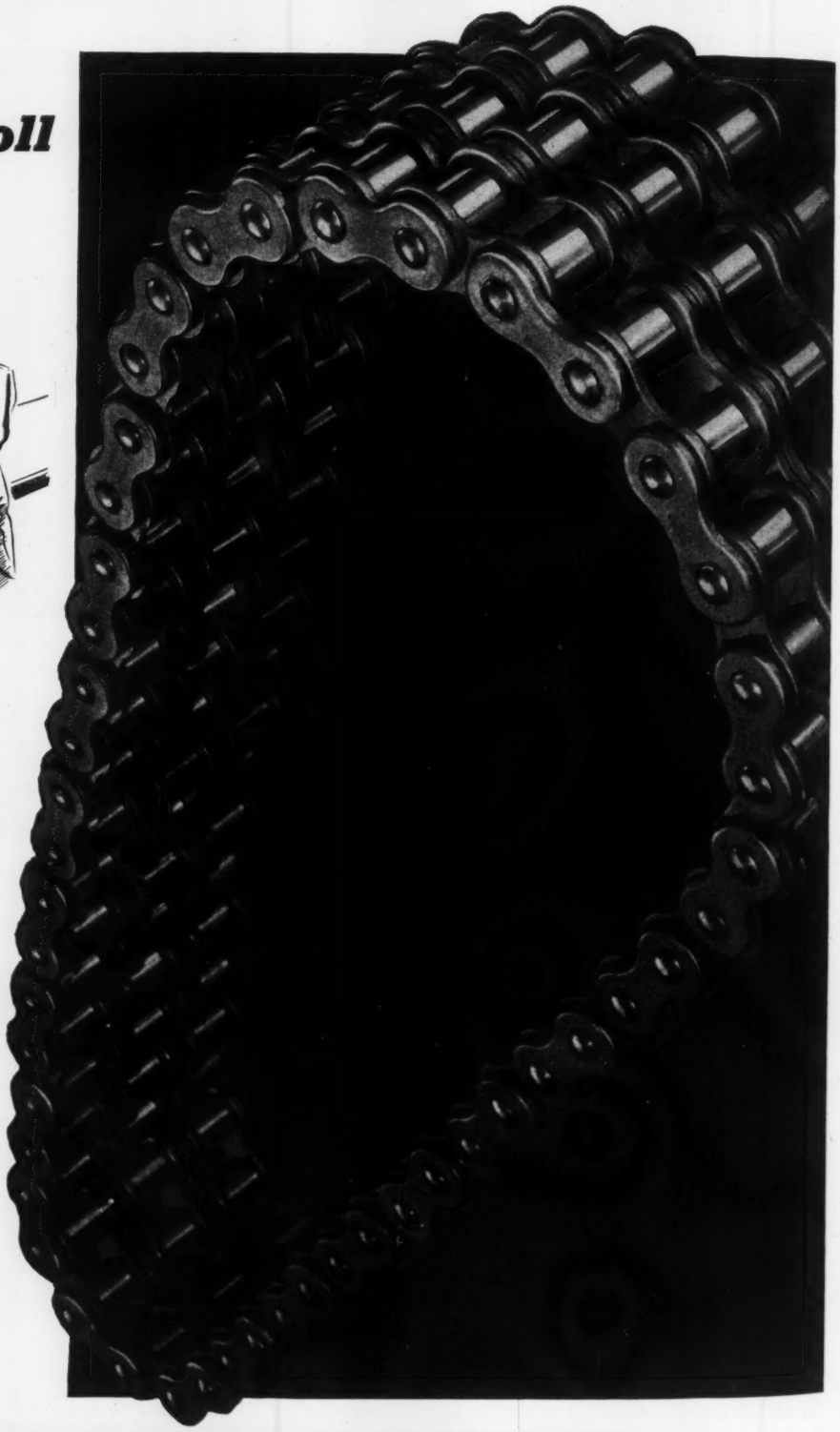
PLASTICS DEPARTMENT

GENERAL ELECTRIC

Do Your Machines Answer: "HERE!"

when the Production-Roll is Called?





Make sure that the production machines you design and build are *power-fit* to maintain their full rated capacity of output under today's non-stop operating conditions. Build the extra strength of Whitney Chains into every drive . . . and get *total transmission* of power to the job, at constant speeds that keep product-quality uniform. These tough alloy-steel roller and silent chains assure top levels of drive-performance at lowest levels of cost, over the longest span of service. So get the *power priority* of Whitney Chains to make your machines 100% fit for defense production.

The Whitney Chain & Mfg. Co.

Hartford, Connecticut

WHITNEY PRODUCTS Roller Chain & Sprockets, Silent Chain & Sprockets, Conveyor Chain & Sprockets, Roller Chain Flexible Couplings, Automatic Load Limiting Sprockets, Automatic Drive Tensioners, Woodruff Type Machine Keys and Cutters

WHITNEY

ROLLER AND SILENT CHAINS FOR POSITIVE POWER TRANSMISSION

Related Design . . . A Feature of Clark Control

One Finger Mechanism Fits an Entire Line of Devices

All of these "3C" switches use the same Finger Contact Mechanism, and the same silver-to-silver Contact Tips. Remove one screw, and the entire Finger Assembly lifts out. A simple twist releases the Contact Bar, but the Pressure Spring is held in place by a retaining stud. By standardizing on Clark Switches, your maintenance problem is simplified; you have less spare parts to carry. Fully descriptive Bulletins on all these Switches are yours for the asking.

OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

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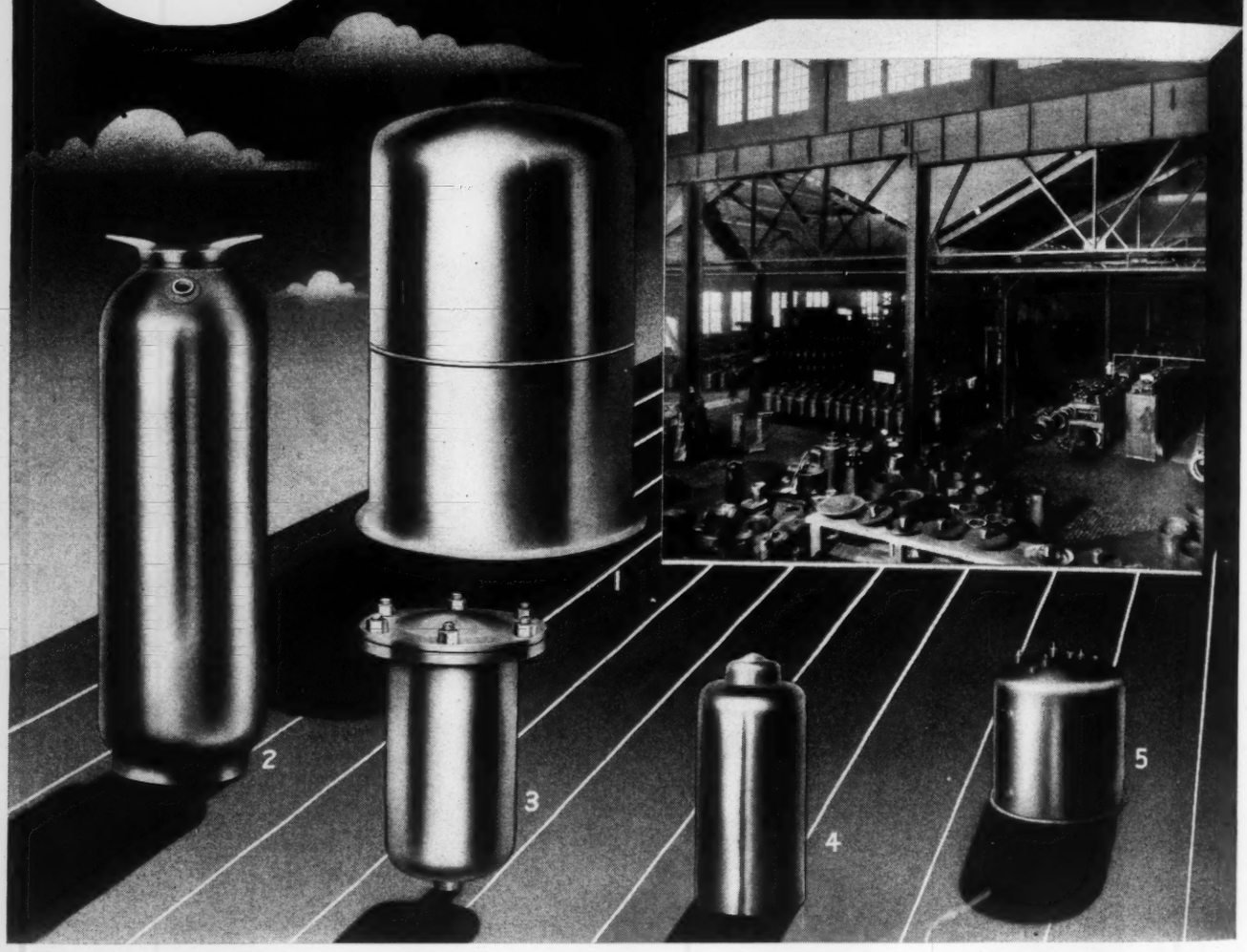
Hackney MILWAUKEE

DEEP DRAWN SHAPES AND SHELLS



CAN A HACKNEY SPECIAL SHAPE SOLVE YOUR PROBLEM, TOO?

● A Hackney deep drawn shell has aided manufacturers in scores of industries to solve their problems—effectively and economically.

Through the use of Hackney design and manufacturing facilities, many concerns have been able to speed up production. Often they have reduced the cost of an individual part. Overall weight, too, is frequently lowered through the use of a Hackney part. At other times strength is increased. Many times manufacturers realize a combination of these and many other important advantages.

Pressed Steel Tank Company specializes in the manufacture of seamless deep drawn shells of various sizes. By means of high pressure hydraulic presses, especially designed for this purpose, the shell is drawn from a solid circular sheet or plate of ferrous or non-ferrous metals. A smooth finish, uniform thickness and temper are assured by Hackney's Special Cold Drawing Process.

Why not consult a Hackney engineer regarding the use of seamless drawn tubes, shells, special cylindrical shapes or pressure tanks. They may represent an improvement for your product. Write for full information today.

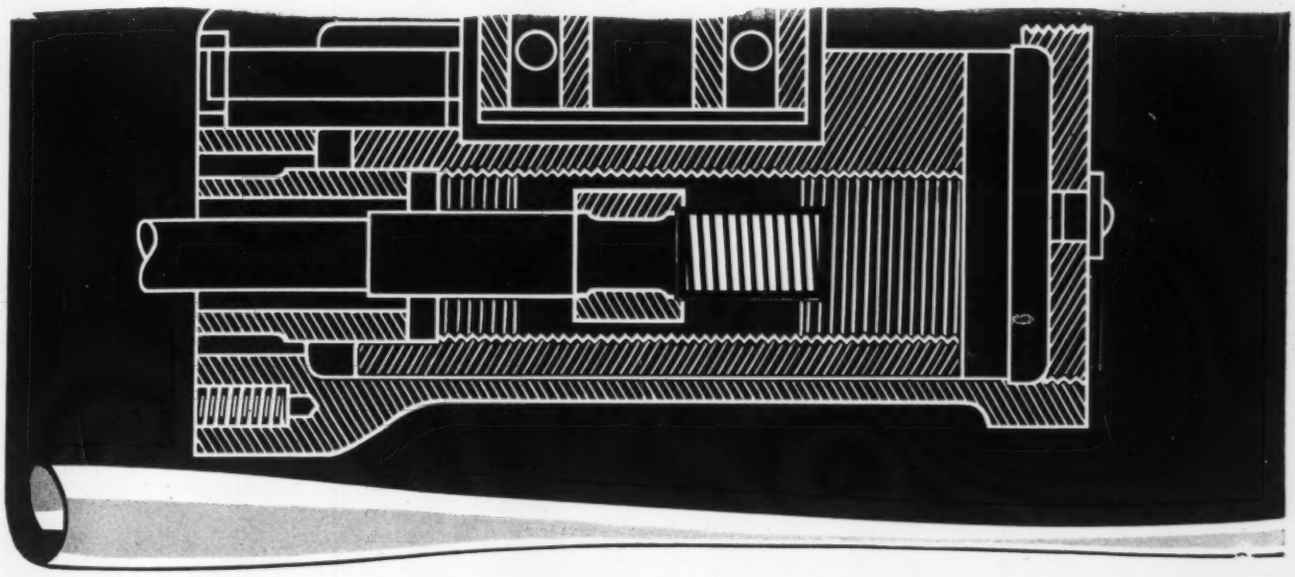
1. Gas-fired boiler tank 29″ diameter, 46⅜″ high. 2. Fire extinguisher tank 16″ diameter, 51″ high. 3. High pressure grease-dispensing tank 10″ diameter, 20″ high. 4. Case for oil-submerged circuit breaker 11″ diameter, 26″ high. 5. Small compressor tank 14″ diameter, 16″ high.

PRESSED STEEL TANK COMPANY

1314 Vanderbilt Concourse Bldg., New York • 208 S. LaSalle St., Room 1587, Chicago
686 Roosevelt Bldg., Los Angeles • 1435 S. 66th St., Milwaukee

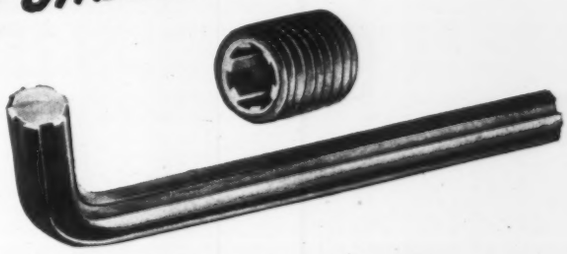
Hackney MILWAUKEE

CONTAINERS FOR GASES, LIQUIDS, AND SOLIDS



It's got to be a LITTLE SCREW... YET HOLD TIGHT UNDER VIBRATION

CONDITIONS: Very small part of a precision product must be fastened so tightly that violent vibration won't loosen it... yet must be easy to disassemble.



What's the Best Fastener?

Contrast These Socket Shapes

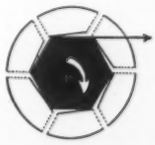
THE BRISTO MULTIPLE-SPLINE SOCKET SCREW

This screw can be set much tighter than ordinary hex screws, because the splines allow use of a rotary driving force that would split or round out the socket wall in other screws. It will not loosen under shock or vibration yet is easily removed by any type of socket wrench.

THEY COST NO MORE

Bristo Multiple-Spline Screws are the perfect fastening for assemblies subject to vibrations, such as electric fans, tabulating machines, refrigerators, oil pumps, cameras, electric razors, etc.

Made as small as No. 4 wire size, they can be used in places inaccessible to ordinary screws.



ORDINARY HEX SCREW: Wrench applies outward expanding force that may split or round out socket walls unless they are thick ferrous metal.

BRISTO SCREW: Locked against the splines, the wrench exerts *contracting* pressure. Greater tightening strength permits use of smaller, thin-walled screws; also non-ferrous metal.

SUPPLY OF WRENCHES FREE WITH EACH 100 SCREWS. A nearby mill supply house can give you quick deliveries.

Send for Free Screws, Wrench and Bulletin 846. Address 122 Bristol Road, Waterbury, Connecticut.

BRISTO MULTIPLE-SPLINE SCREWS

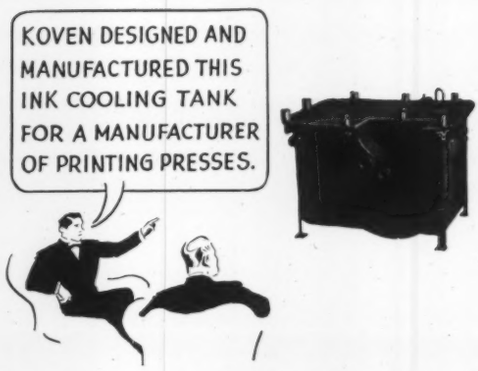
SET FASTER... SET EASIER... SET TIGHTER

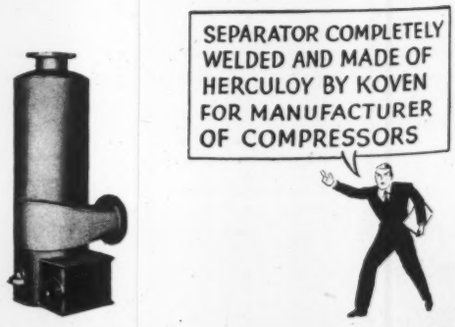
The BRISTOL COMPANY MILL SUPPLY DIVISION WATERBURY, CONN.

Perfect Cooperation

With skilled workmen and efficient machinery at a premium today Auxiliary Manufacturing is doing an important job in keeping nationwide production at Full Speed! This accounts for the many leading manufacturers who effect a distinct saving in both time and money by relying upon the vast KOVEN Fabricating Facilities and Staff, rather than their own, to produce to specification one or more of the parts required in the manufacture of their finished products.

If the Production of any part you require is giving you difficulty, inconvenience and higher costs, consult KOVEN. Their wide experience enables them to supply any part you require Quality-Made and Economically!





L. O. KOVEN & BRO., INC.

154 OGDEN AVENUE JERSEY CITY, N. J.

PLANTS: JERSEY CITY, N. J., DOVER, N. J.

VICKERS

Gear Type FLUID MOTORS

DEVELOP ROTARY MECHANICAL POWER FROM OIL HYDRAULIC PRESSURE

VICKERS
Exclusive Hydraulic Balance Construction

means much

(1)
LONGER LIFE

(2)
HIGHER EFFICIENCY

(3)
GREATER PRACTICAL OPERATING PRESSURE

(4)
MORE COMPACT

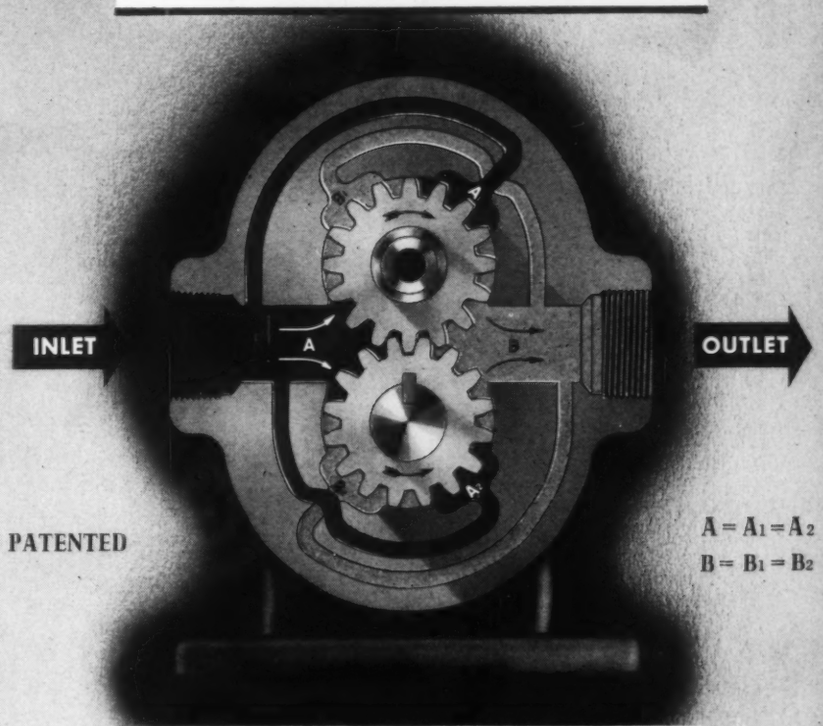
Vickers Gear Type Fluid Motors provide a compact efficient means for applying variable speed rotary power. They have variable horsepower (fixed torque type) characteristics; they can be reversed and controlled readily by other Vickers Hydromotive Control devices in the circuit.

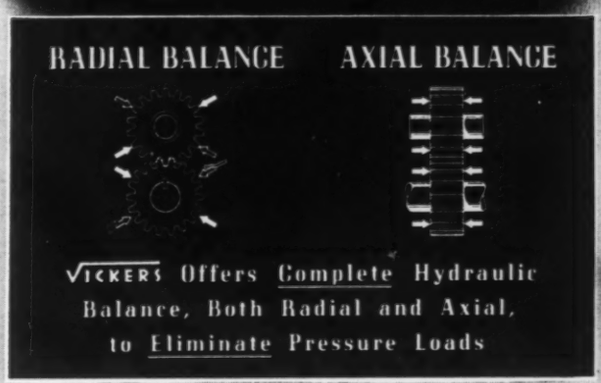
The schematic diagram shows how Vickers patented "Hydraulic Balance" construction is applied to Vickers Gear Type Fluid Motors. This "Hydraulic Balance" construction and its advantages are available on no other fluid motors.

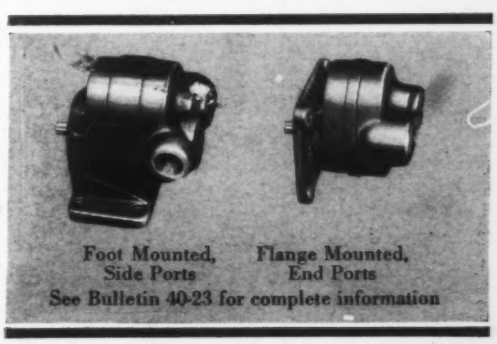
Here is further evidence of the engineering development and research that assures the unique performance of all Vickers Hydromotive Equipment.

VICKERS *Incorporated*
1430 OAKMAN BLVD., DETROIT, MICHIGAN

Bearing Loads are Cancelled Out




RADIAL BALANCE
AXIAL BALANCE
VICKERS Offers Complete Hydraulic Balance, Both Radial and Axial, to Eliminate Pressure Loads



ROSS Air Control VALVES ... Always Dependable AND EASY TO INSTALL

THE BRIDLE FOR AIR HORSEPOWER

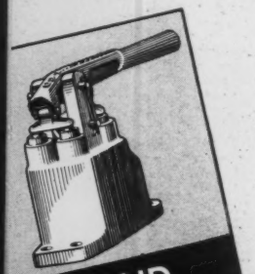
ROSS VALVES installed 15 years ago are still giving satisfactory daily service . . . . one large manufacturer now using over 3500 Ross Valves . . . . past reputation sells them . . . . performance brings repeat orders.

Ross Valves may be installed in any relative position that the design of your machine requires. They may be mounted vertical, inverted, or at any conceivable angle . . . and may be operated by push-button, by foot action, by pulling a lever down or up or side-ways, or by automatic control.

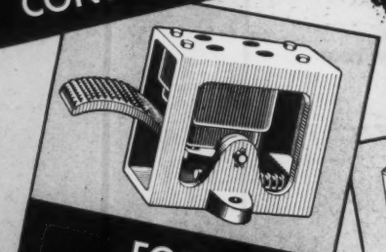
All ports on one face makes the installation of Ross Valves simple, quick and inexpensive. Your air actuated equipment deserves the best . . . . standardize on Ross Valves.

ROSS Operating VALVE COMPANY
6485 EPWORTH BLVD · DETROIT, MICHIGAN

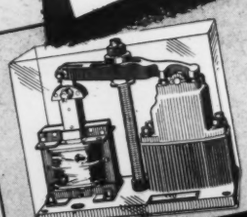
★ A SIZE AND TYPE FOR EVERY OPERATION ★



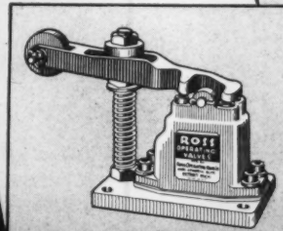
HAND CONTROL



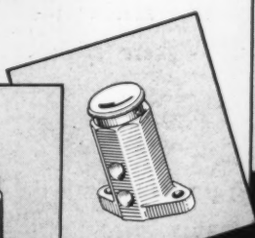
FOOT CONTROL



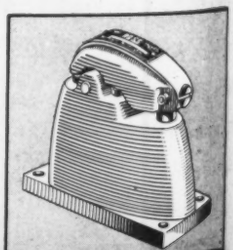
SOLENOID CONTROL



MECHANICAL CONTROL

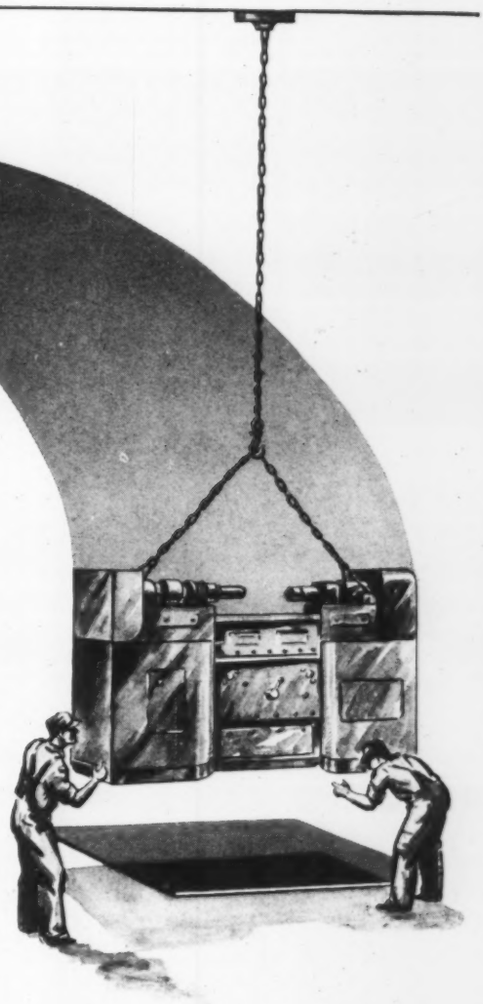


PILOT CONTROL

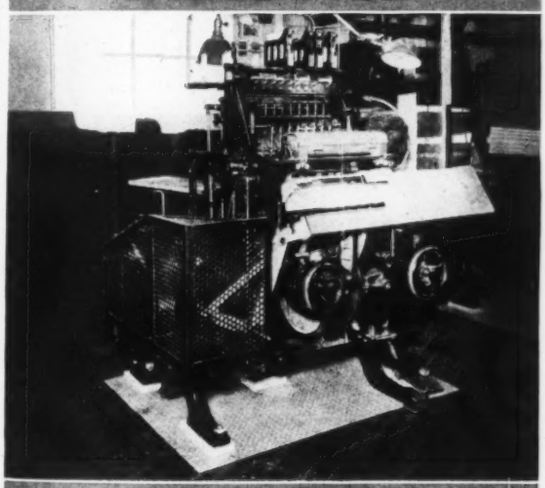


ALL AIR CONTROL

DON'T BE OLD-FASHIONED !



THIS MACHINE WAS RELOCATED



DUE TO STYLE CHANGES

• In order to group machinery for more efficient production, this machine was re-located and quickly reset on Unisorb Cushion Machine Mountings without bolting down. In addition, the Unisorb isolates the vibration of the machine from the building.

WHY not re-locate your vital machines in about half the time it ordinarily takes? Get Unisorb Cushion Machine Mountings and see for yourself. A trial installation will prove the point . . .

No bolts, no floor preparation, and what a saving in time and money!

Our booklet, "UNISORB IN THE INDUSTRIAL PLANT" shows actual installations—send for your free copy today.

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Small Motor Starting Switches

ACROSS-THE-LINE TYPE Tumbler Switches, without overload protection . . . Give positive control for motors; especially suitable for oil burners, refrigerators, motor-driven machinery and lighting loads.

These switches have rugged, durable mechanisms built to perform with the sturdy integrity characteristic of Arrow-H & H Lines. Bakelite arc snuffers increase breaking capacity; kick-off release mechanically starts the switch blades in motion and prevents sticking; extra-heavy blades and contact jaws increase current-carrying capacity.

Different styles of mounting are supplied for a wide range of machine-design requirements. Separate switch units are available for installations in switch housings built into motor-driven machinery.

No. 6808 (upper right) is a double-pole switch for single phase motors; No. 7808 (lower left) is 3-pole for 3-phase jobs. Also, the line includes 3-way, 4-pole and 2-speed reversing switches. All have horsepower ratings . . . Everything you may need in this line will be found in Motor Starting Switch Catalog No. 8-M — on request.

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THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

Lock Washer can't come off . . . but is free to rotate!

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speed up assembly and protect performance for SCHICK SHAVERS

In the assembly of the nationally famous Schick Shavers, manufactured by Schick Incorporated of Stamford, Connecticut, great care is taken to have all parts fastened securely and thoroughly protected against vibration. The illustration above shows the "whisk-it"—the part that catches the beard clippings—being fastened with SEMS Units. The operator quickly picks up the single unit and drives it home. No time wasted putting the lock washer on the screw—no chance to "forget" the lock washer which keeps the screw locked tight. Take advantage of this assembly efficiency and product protection which SEMS Fastener Units provide—write for testing samples today!

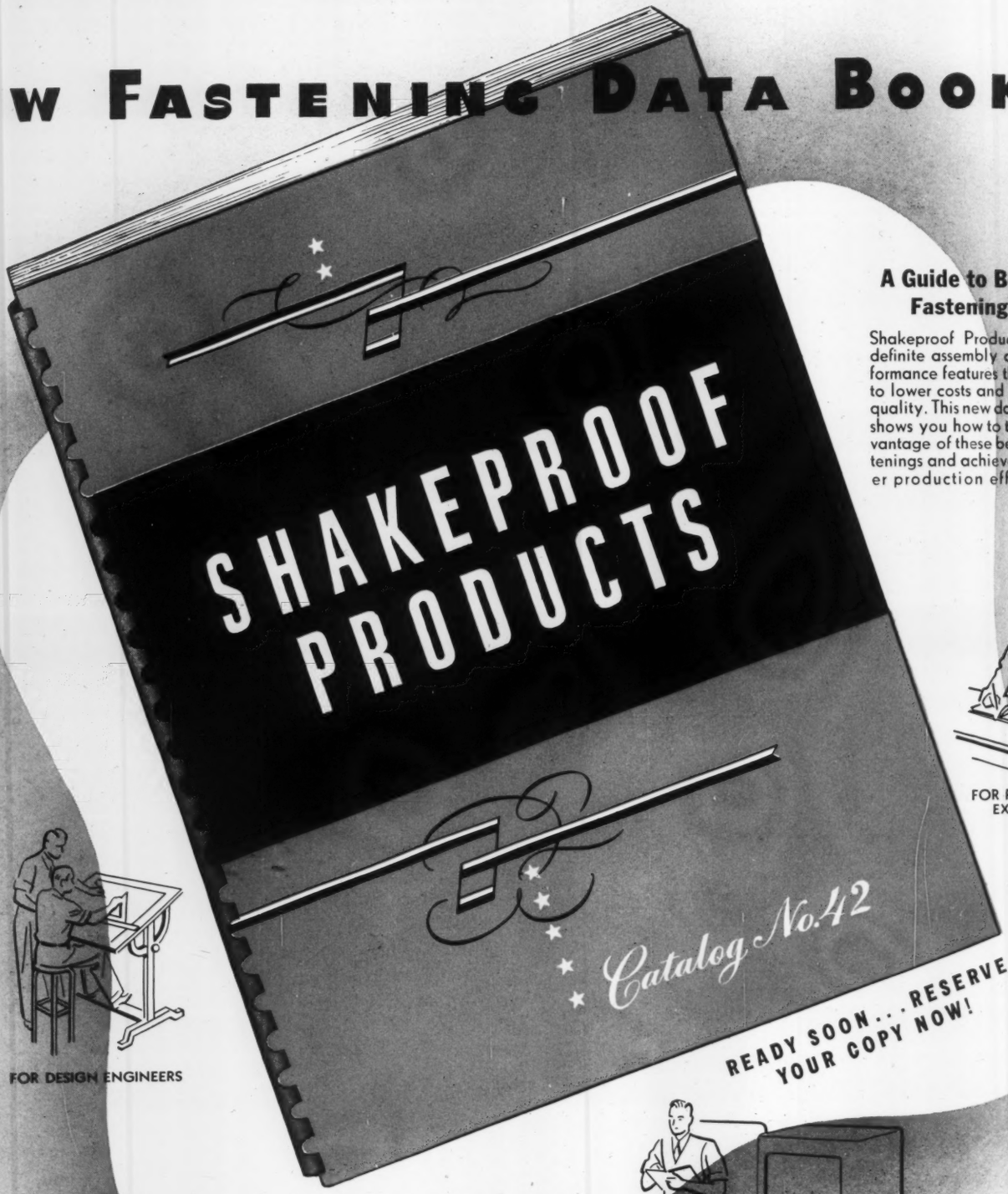
View of one part of two Schick Shaver assembly lines on which SEMS Fastener Units are used.

Operator completing attachment of the "whisk-it" to the Schick Shaver.

New **SHAKEPROOF CATALOG**

See Next Page

NEW FASTENING DATA BOOK!



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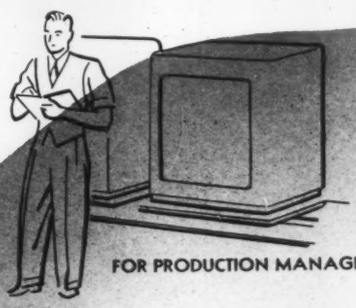

FOR PRODUCTION MANAGERS

THE new Shakeproof Catalog No. 42 provides a complete and detailed presentation of all Shakeproof Products. Its one hundred and forty pages are filled with information and illustrations of special interest for design engineers, production managers and purchasing executives. Each Shakeproof product is described in detail and full engineering data is given. In addition, application suggestions and other technical material helpful in securing greater fastening efficiency has been included. Reserve your copy of this outstanding fastening data book by mailing a request on your company's stationery—copies will be distributed as soon as available.

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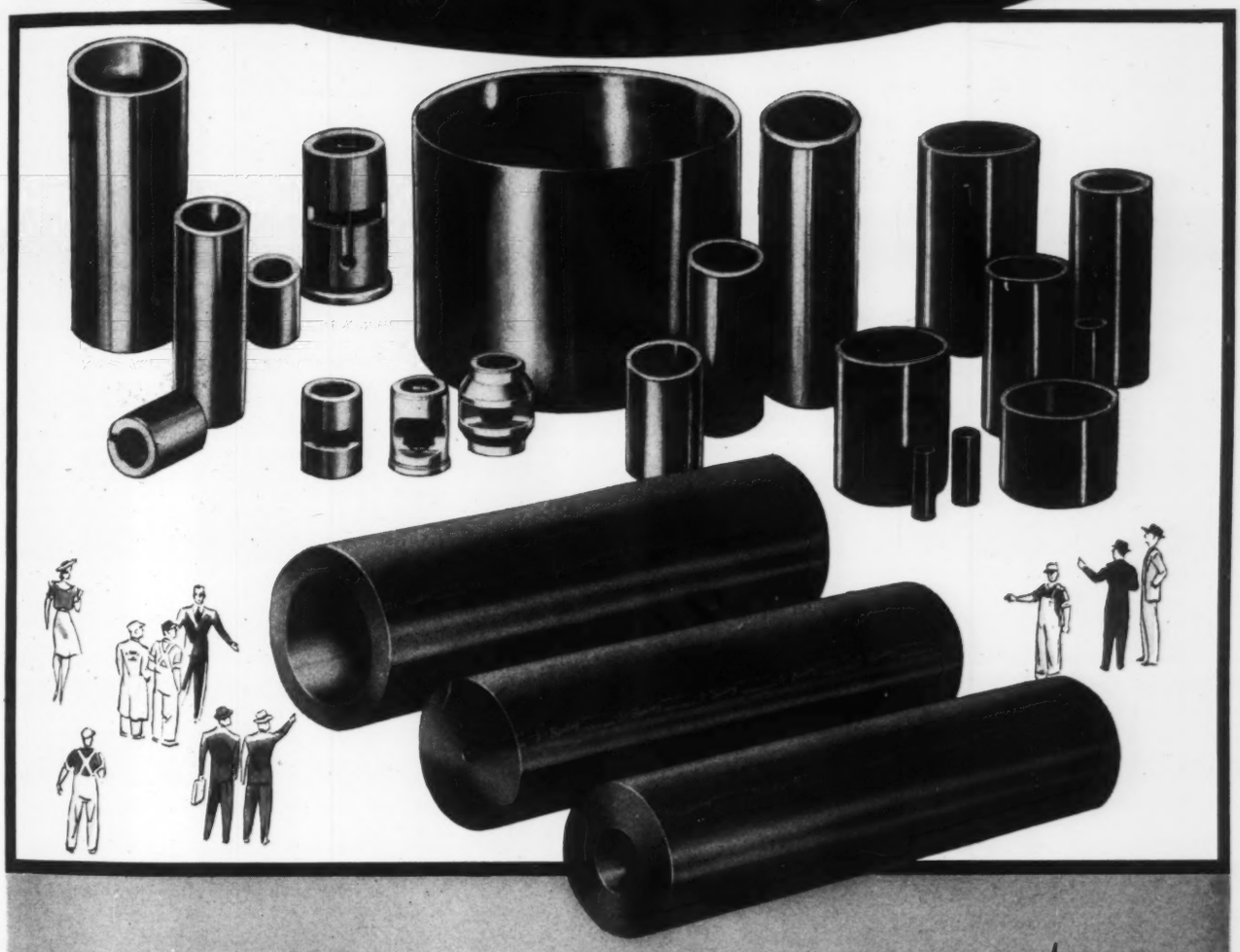

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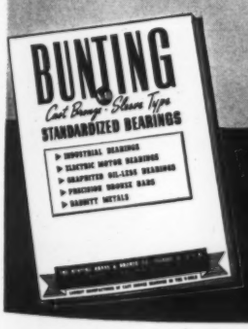

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BABBITT METALS

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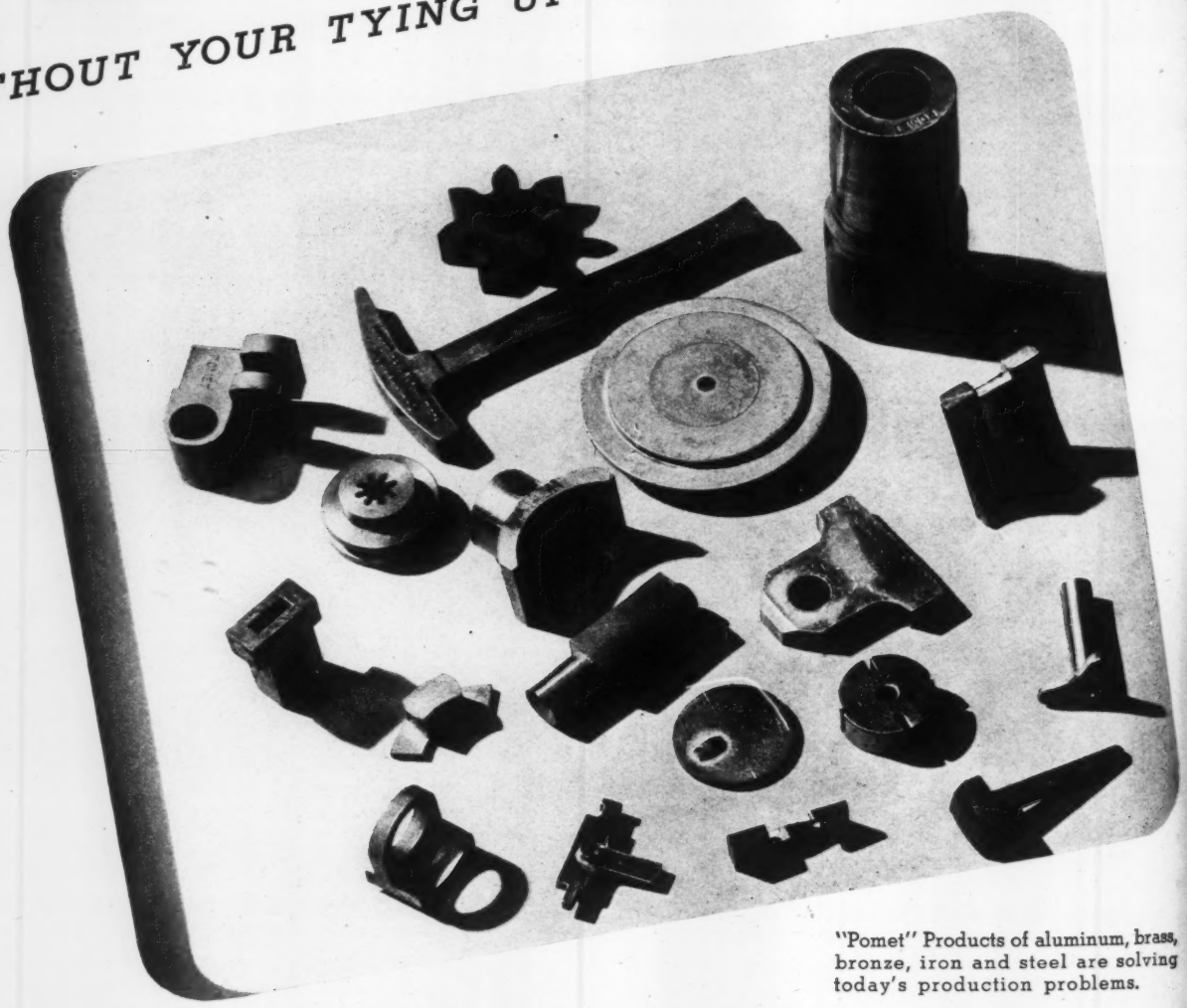
WITHOUT YOUR TYING UP—OR BUYING—EQUIPMENT



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7½ hp, 600 v

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BULLETIN 609 ACROSS-THE-LINE STARTERS

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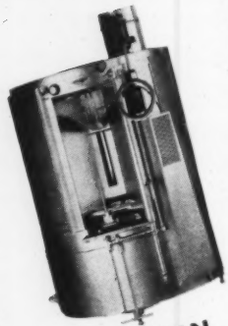
THE MANUAL STARTER for 1,001 JOBS



MILK CAN WASHERS

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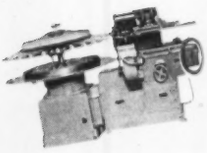
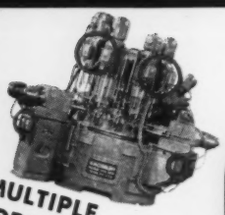
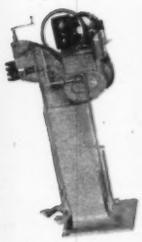


BAG SEALING MACHINES

BOTTLE FILLERS

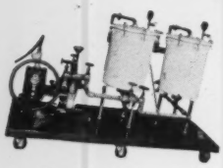


MULTIPLE DRILLS

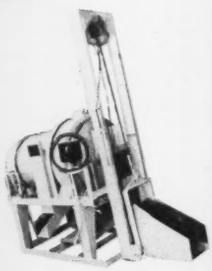


ROTARY SHEARS

BURRING MACHINES

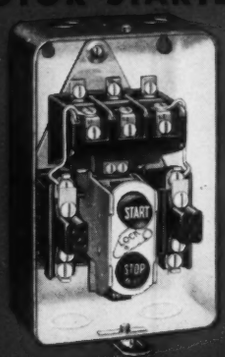


FILTERS

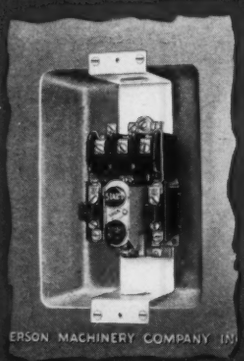


METAL CLEANERS

BULLETIN 609 MOTOR STARTERS



This open view of the Bulletin 609 hand-operated motor starter shows the compact switch mechanism mounted in the standard general-purpose enclosure.



The above illustration shows the Bulletin 609 starter arranged for flush mounting in a machine base or wall recess.

Allen-Bradley Co.
1333 S. First St., Milwaukee, Wis.

GRINDERS

TOOL GRINDERS

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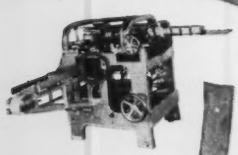
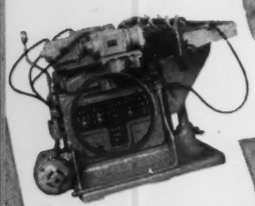
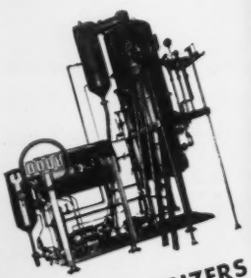


WRAPPING MACHINES

MULTIPLE SPINDLE MACHINES



WOOD BORING MACHINES



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LUBRICATION • LIQUID TRANSFER

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Whether you are considering a design which includes coolant, hydraulic operation, lubrication or liquid transfer, it will pay you to get the facts about Tuthill precision-built pumps. They are engineered for the job and can be furnished in various capacities from 1 to 200 gallons per minute at pressures up to 350 psi.

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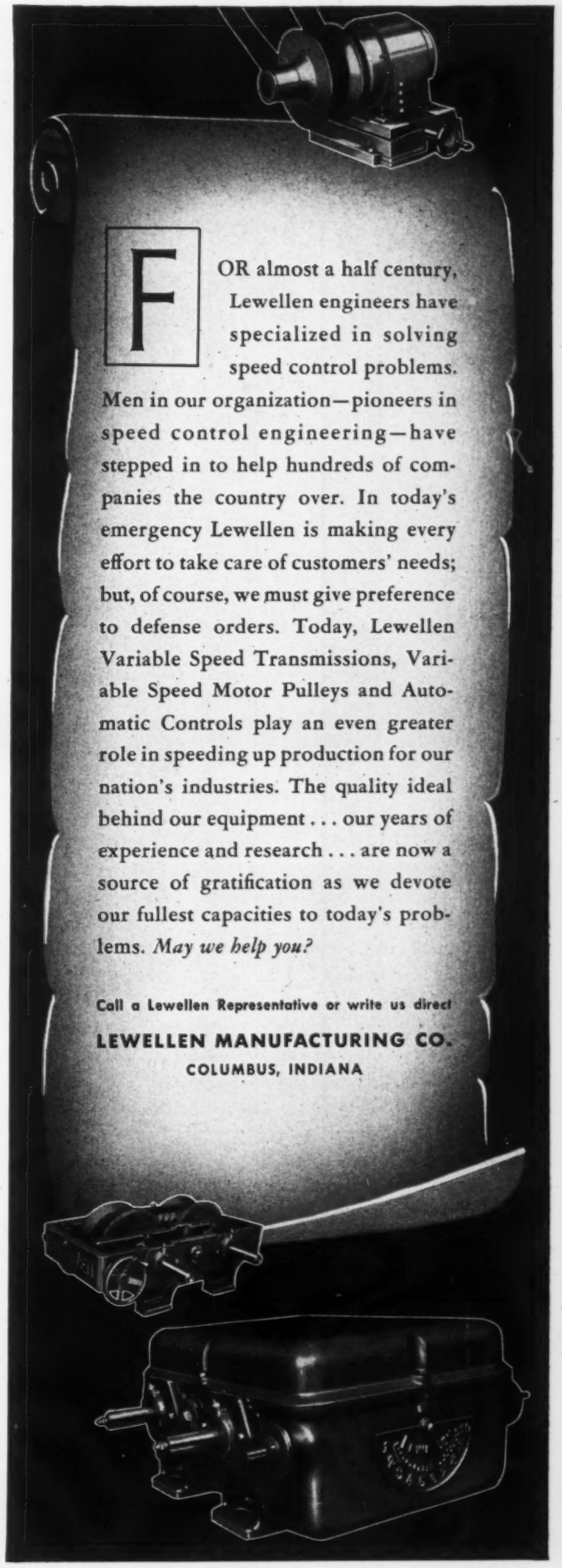

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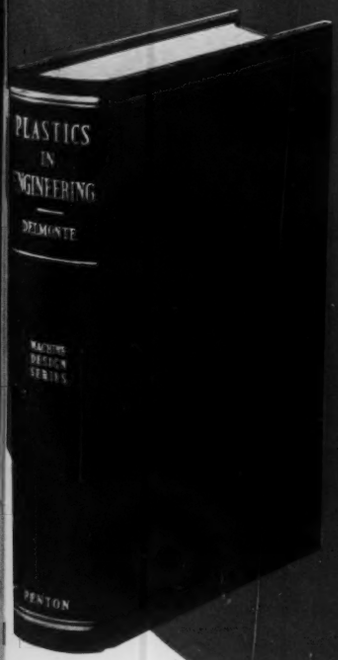

Over six hundred pages of authentic information on plastics. Answers practically all questions that confront designers faced with the necessity of securing information on plastic materials of all kinds.

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Since publication of the First Edition of "Plastics in Engineering", less than two years ago, the plastics industry has undergone rapid advancement . . . resulting in new and important developments for the design engineer working with these materials.

Because national emergency has necessitated withholding, or at least curtailing, use of strategic metals for defense, a minor revolution in the design of machine parts has occurred. The result is that now—more than ever before—manufacturers must become acquainted with ways of adapting plastics to their design program.

A careful study of the contents of "Plastics in Engineering" will show its extremely broad and inclusive consideration of plastics . . . will give an idea as to why it has become the accepted authority on plastics.

New chapters have been added and technical data have been reorganized to permit more easy reference to the text material. Extruded plastics and resin-bonded plywoods, for example, are given more prominence in the Second Edition because of tremendous expansion in these developments during the past year.

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HELPFUL LITERATURE

for DESIGN EXECUTIVES

1. Quick Drying Finishes

McDougall-Butler Co.—4-page folder describes "Hardcote" one hour dry finishes for use on inside or outside surfaces of wood or metal. These finishes may be applied by spraying, brushing or dipping and provide durable lasting finish.

2. Decimal Wall Chart

Frederick Post Co.—26 x 39-inch wall chart shows all decimal equivalents from 1/64 to 63/64 inch. It is printed in large heavy type 1¼ inches high and is intended for posting on wall of drafting room for easy reference.

3. Titanium Data

Titanium Alloy Manufacturing Co.—114-page illustrated handbook, "Titanium and Its Use in Steel," covers history and properties of titanium, as well as its use in steel and its effect on properties of various types of steels and alloys. Diagrams, photomicrographs and other data

4. Textile Motors

Westinghouse Electric & Manufacturing Co.—4-page illustrated folder No. D.D. 3175 describes lint free motors between 1½ and 15 horsepower for textile industry. Cutaway illustration shows how lint is prevented from clogging windings of motor. Other features such as one-piece skeleton frame and sealed in bearings are described.

5. Metering Valve

Vickers, Inc.—4-page illustrated bulletin, "Vickers Flow Control and Overload Relief Valves," explains operation, design and application of these units which provide adjustable metering and maintain set rate of flow regardless of variation in imposed fluid pressure. Performance data and installation suggestions are given.

6. Bronze Bearings

R. W. Rhoades Metaline Co.—16-page illustrated catalog No. 5 enumerates features and advantages of "Metaline" oilless bronze bearings. Three sections describe lubricating properties of product, various types and ranges of application for oilless bearings and detailed data for use in preparing specifications.

7. Lubrication System

Farval Corp.—8-page illustrated bulletin, "Why Farval?", describes design, operation and application of "Farval" centralized system of lubrication. In addition to explaining system and its component parts, charts outline savings claimed to be effected by application of equipment.

8. Air Cleaners

Donaldson Co.—12-page illustrated bulletin is issued to commemorate company's twenty-fifth anniversary. It covers history and development of company, personnel, manufacturing facilities, and applications of "Oil-Washed" air cleaners. Various models of cleaners and their usage on equipment are pictured.

9. Zinc

New Jersey Zinc Co.—4-page illustrated bulletin "Zinc In Defense" outlines diversified applications of zinc, zinc alloys and zinc compounds. Series of illustrations with brief explanatory captions show applications of paint, rubber, brass, ceramics, galvanized sheets and boiler plate. Included is statement of company policy to non-defense zinc users.

10. Air Products

Air Reduction Sales Co.—54-page plastic-bound illustrated bulletin gives detailed description of activities of company and its five subsidiaries. Text, amplified with pictures and diagrams, explains methods, markets and nature of the business. Multi-colored chart shows graphically diversification of services to business and industry in general.

11. Annealing Nickel Alloys

International Nickel Co.—16-page illustrated bulletin T-20 deals with "Annealing Nickel, Monel and Inconel." Practical methods and equipment for soft annealing, bright annealing, temper annealing and stress-equalizing annealing cold-worked materials are described and illustrated by typical mechanical properties. Selection and use of fuel, furnaces and furnace atmospheres; pyrometry; rate of cooling; and effect of cold work previous to annealing are covered.

12. Rubber Parts

Monarch Rubber Co.—6-page illustrated folder explains facilities of company and typical molded and extruded rubber products produced. Some of operations in manufacture of rubber parts are shown pictorially and explained.

13. Machine Safety Control

Prosperity Co.—4-page illustrated bulletin No. VD-7 describes "Lok-Air" two-hand safety control for pneumatic control of power machinery. This device is applicable to all types of power machines and is claimed to provide positive tamperproof protection for operators.

14. Steel Spoke Wheels

Geneva Metal Wheel Co.—24-page illustrated section 2 of Catalog No. 21 presents description and complete specifications on line of "Spoketite" steel spoke wheels for application to all types of wheeled vehicles, including carts, wheelbarrows, scoops, tractors, handtrucks and wagons.

15. Abrasion Tester

Taber Instrument Co.—6-page illustrated bulletin No. 4012 is descriptive of research model "Taber Abraser" which may be used for evaluating resistance of surface finishes to rubbing abrasion. Range of application includes paint, lacquer, electroplated and plastic surfaces, as well as fabrics.

16. Air Compressor Selector

Quincy Compressor Co.—Slide-rule type cardboard selector aids in selecting correct size and type of compressor for specific job. One setting of scale shows correct compressor model number, free air delivery, revolutions per minute, piston displacement and motor horsepower required. Pressures covered range from 30 to 250 pounds.

17. Plastics

Elmer E. Mills Corp.—24-page illustrated bulletin, "Injection Molded Plastics," explains facilities of company, discusses thermoplastics and how they are molded, and shows typical products manufactured. Cellulose acetate, cellulose acetate butyrate, acrylic, vinyl, polystyrene and ethyl cellulose plastics are described. Properties of injected molded plastics are given in large chart.

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HELPFUL LITERATURE

18. Speed Reducers

D. O. James Co.—48-page illustrated bulletin No. 19 contains complete engineering data and prices on parallel shaft continuous-tooth herringbone speed reducers. Advantages and features, general specifications, ordering information, and explanation of rating tables are enumerated. Six pages of installation photographs depict typical applications.

19. Machine Tool Motors

General Electric Co.—2-page catalog section No. GEA-3579 describes line of fractional horsepower motors which are built specifically to meet requirements of machine tools and other industrial applications where frequent start-stop service, plugging, and dust-metal atmospheres are encountered. Photographs show motor parts and types of mounting.

20. Chromium Alloy Steel

Electro Metallurgical Co.—Engineering discussion shows, by results of large number of tests, how mechanical properties of high-chromium steels are markedly improved by additions of nitrogen to supplement amount of this element normally present in all steels. Proper procedure and precautions to be observed in treating steels with nitrogen are enumerated.

21. Bearings

Bantam Bearings Corp.—8-page illustrated regular publication, "The Bearing Engineer," contains informative articles and technical data concerning "Torrington" needle bearings and "Bantam" ball bearings and their applications in all types of equipment.

22. Pipe Cleaning Brushes

National Electric Manufacturers Co.—2-page illustrated bulletin 10241 describes "Nemco" brushes for cleaning pipe and tube. Flexible couplings for loads from ¼ to 25 horsepower are also described. These couplings correct for axial misalignment, non-parallelism and angularity.

23. Industrial Lighting

Fostoria Pressed Steel Co.—12-page illustrated bulletin, "Balanced Lighting," explains proper lighting and benefits resulting therefrom, and shows typical applications of "Localites" and fluorescent fixtures for adequate industrial lighting.

24. Hydraulic Controls

Hydraulic Controls, Inc.—12-page illustrated bulletin gives recent developments in systems for hydraulic control of straight line motion. Line drawings show typical hydraulic circuit assemblies and details of "Hycon" pump, pressure control valve and other accessories.

25. Solenoids

National Acme Co.—20-page illustrated bulletin No. EM-41 is descriptive of "Namco Stellite Welded" solenoids which are reinforced at points of wear with hard facing material. List of sizes, typical mountings, dimensions, specifications and full information on all units in line are included.

26. Combustion Equipment

Babcock & Wilcox Co.—8-page illustrated booklet, "New Equipment and Data Digest," describes briefly literature available on boilers, burners, steam separator, furnaces, firebrick, boiler tubes, boiler and steam control, and other related subjects.

27. Metal Fatigue

Nitralloy Corp. — 45-page booklet, "Fatigue of Metals—Some Facts for the Designing Engineer," is technical paper on conditions which limit stress in metals by fatigue. S-N curve, combined stresses, alternating stresses, homogeneity—scatter, stress raisers, local stresses, tensile strength vs. fatigue limit and nitriding are some of many subjects covered.

28. Variable Speed Drive

Lewellen Manufacturing Co.—48-page illustrated catalog No. 40 lists and describes complete line of variable speed transmissions and controlling devices. Details of design and operation of equipment are presented. Complete specifications, engineering data and application details are included.

29. Defense Production

Link-Belt Co.—12-page illustrated bulletin No. 1917, titled "Just Another Job," explains part Link-Belt Co. is playing in producing defense materials, either directly or indirectly. Products are shown in use and some of defense materials are pictured.

30. Hydraulic Drives

Twin Disc Clutch Co.—24-page illustrated bulletin No. 132 has for subject matter nature of hydraulic drives, design and performance of hydraulic clutches and hydraulic torque converters and applications of hydraulic clutches and torque converters. Diagrams and charts amplify text.

31. Speed Reducers

Cleveland Worm & Gear Co.—8-page illustrated bulletin, "Background," explains claim of long range, economical operation of "Cleveland" worm gear speed reducers by quoting from series of letters from manufacturers in various industries who have used these drives for past 15 or 20 years. Applications in each industry are shown and explained.

32. V-Belt

Allis-Chalmers Manufacturing Co.—8-page illustrated bulletin No. B-6190 explains how "Super-7" V-belt provides long life and high efficiencies because of more and stronger cords, cushion rubber zone and duplex-sealed cover. Selection table and price list for sizes available in stock are included.

33. Die Castings

Madison-Kipp Corp.—28-page illustrated bulletin No. 200 gives general information on company's facilities to produce high pressure aluminum die castings and details of their lubrication equipment and air tools. Each of 28 pages is devoted to general description of different products.

34. Speed Reducers

Foote Bros. Gear & Machine Corp.—18-page illustrated bulletin No. 104-S deals with "IXL" single type speed reducers and speed increasers. It contains description of manufacturing processes, explanation of needs for high speed reducers and increasers, AGMA ratings, methods of selection, and dimensional views of units.

35. Glass Insulation

Corning Glass Works—Illustrated reprint, "The Dielectric Strength of Glass—An Engineering Viewpoint," by E. B. Shand, discusses dielectric failure of glass, factors governing failure and includes curve data. Curves are given on disruptive strength, breakdown characteristics, oil puncture tests and characteristics of glass and porcelain.

36. Metal Working

Scovill Manufacturing Co.—20-page illustrated booklet traces company's development from its inception in 1802 up to the present time and shows scope of its five divisions—illustrations show factory scenes and many of company's diversified products.

37. Induction Hardening

Ohio Crankshaft Co.—16-page spiral-bound illustrated bulletin No. 10 gives complete data on the "Tocco" process of induction hardening. Process is explained. Metallurgy and equipment are covered in detail. Typical applications are illustrated and described.

38. Drafting Machine

V. & E. Engineering Co.—1-page bulletin describes "Veeco" drafting machine which features convenient indexing, smooth elbow brake, full circle baseline setting, central skid button, positive scale holder and positive band tightening device.

39. Small Bearings

Miniature Precision Bearings—8-page illustrated catalog No. 41 gives details of company and describes and gives applications of radial series, and self aligning pivot series of miniature ball bearings. Specifications, dimensions, tolerances and other data are given.

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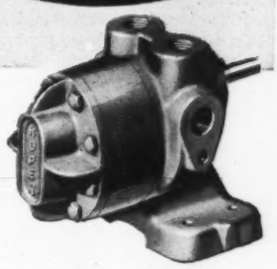

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(For illustrations of other outstanding machinery see pages 80-81)

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*Two-row corn harvester, Allis-Chalmers Mfg. Co., Milwaukee.

Air Conditioning

Combination exhauster and filter, The Hisey-Wolf Machine Co., Cincinnati.
Liquid cooling systems, Worthington Pump & Machinery Corp., Harrison, N. J.
*Oil-fired air conditioner, Chrysler Corp., Airtemp Div., Dayton, O.
*Twin-clock thermostat, Perfex Corp., Milwaukee.

Aircraft

*Pursuit plane, Lockheed Aircraft Corp., Burbank, Calif.

Automotive

Lubrication barrel pumps, Alemite Div., Stewart-Warner Corp., Chicago.

Baking

Loop proofer, J. H. Day Co., Cincinnati.
Midget dough roller, Anetsberger Bros., Chicago.
Rotary pie machine, Colborne Mfg. Co., Chicago.

Domestic

Automatic toaster, Westinghouse Electric & Mfg. Co., Mansfield, O.
Radio-phonographs, Wilcox-Gay Corp., Charlotte, Mich.
Refrigerator, Edison & General Electric Appliance Co. Inc., Chicago.
Towel dryer, St. Charles Mfg. Co., St. Charles, Ill.

Finishing

Automatic metallizing machine, U. S. Galvanizing & Plating Equipment Corp., Brooklyn, N. Y.
Automatic spray machine, Eclipse Air Brush Co., Newark, N. J.
Polishing lathe, Walker-Turner Co. Inc., Plainfield, N. J.
Rotary automatic polisher, Hammond Machinery Builders Inc., Kalamazoo, Mich.
*Gear finishing machine, The Fellows Gear Shaper Co., Springfield, Vt.
Two series portable spray painting air compressing outfits. The DeVilbiss Co., Toledo, O.
Barrel plating machine, The Udylite Corp., Detroit.

Heat Treating

Electrical induction unit, Ohio Crankshaft Co., Cleveland.
Automatic surface hardener, Gleason Works, Rochester, N. Y.
Automatic flame hardener, Selas Co., Philadelphia.
Thermonic induction heating generators for surface hardening, Induction Heating Corp., New York.
Large model electric furnace, Sentry Co., Foxboro, Mass.
Demagnetizer, Magnetic Analysis Corp., Long Island, N. Y.

Industrial

Floor sanding and cleaning machine, G. H. Tennant Co., Minneapolis.
Light inspection motor car, The Buda Co., Harvey, Ill.
Unit dust collector, Aget-Detroit Mfg. Co., Detroit.
Light inspection motor car, The Buda Co., Harvey, Ill.

Laundry

Mending machine, Mendex Corp., Cleveland.
Starching machine, Prosperity Co. Inc., Syracuse, N. Y.
Two-lay sleeve press, Prosperity Co. Inc., Syracuse, N. Y.
Hand finishers, G. H. Bishop Co., Chicago.

Materials Handling

Electric hoist cranes, Northern Engineering Works, Detroit.
Motorized roll grab, The Cleveland Crane & Engineering Co., Wickliffe, O.
Vibratory feeder conveyors, Syntron Co., Homer City, Pa.

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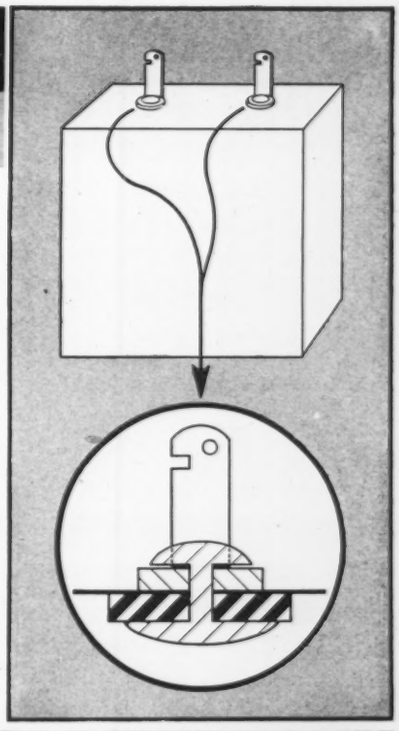

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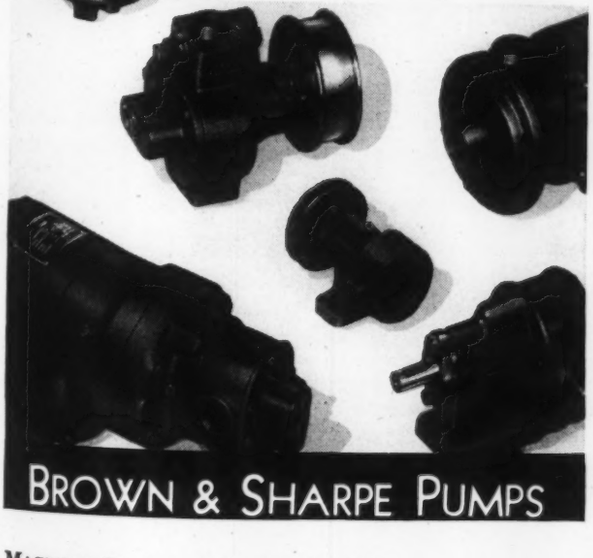

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Travel batch scale car, Cleveland Tramrail Div., The Cleveland Crane & Engineering Co., Wickliffe, O.

Metalworking

Hydraulic press, E. W. Bliss Co., Brooklyn, N. Y.
Hydraulic broaching machine, The American Broach & Machine Co., Ann Arbor, Mich.
All-purpose milling machine, Portman Machine Tool Co., Mount Vernon, N. Y.
Vertical milling machine, Shields Mfg. Co. Inc., Long Island City, N. Y.
Automatic punching and riveting machine, Engineering & Research Corp., Riverdale, Md.
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Coil winder, Globe Tool & Engineering Co., Dayton, O.
Spur gear hobber, Triplex Machine Tool Co., New York.
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*Thread grinder, Ex-Cell-O Corp., Detroit.
*Milling machine, Cross Gear & Machine Co., Detroit.
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Automatic aluminum aircraft piston buffer, Udylite Corp., Detroit.
Vertical miller, Shields Mfg. Co., Long Island City, N. Y.
Cold steel plate bender, J. A. Richards Co., Kalamazoo, Mich.
Hydraulic press, E. W. Bliss Co., Toledo.
Automatic rough, semifinish and finish ream machine, W. F. & John Barnes Co., Rockford, Ill.
Automobile crankshaft contour superfinish machine, Foster Machine Co., Div. International Machine Co., Elkhart, Ind.

*Illustrated in pictorial center spread, Pages 80-81.

Quarry

Air-controlled shovel, Osgood Co., Marion, O.
Portable crane and hoist, Diamond Iron Works Inc., Minneapolis.
Combination shovel, dragline and crane, Lima Locomotive Works Inc., Lima, O.
Jaw crusher, Pioneer Engineering Works, Minneapolis.

Restaurant

Odor adsorbor, Dorex Div., W. B. Connor Engineering Corp., New York.
Heavy-duty electric knife sharpener, E. E. Krumerich Co., Akron, O.

Textile

Redrawing machine, Atwood Machine Co., Stonington, Conn.
Yarn conditioner, Seydel-Wooley & Co., Atlanta, Ga.
Heavy-duty calender, Textile Finishing Machinery Co., Providence, R. I.
Automatic self-cleaning strainer, H. A. Brassert & Co., Pittsburgh.
Rotary machine for screen printing, Roto-Matic Screen Printing Ltd., New York.
Two-roll micro set padder, H. W. Butterworth & Sons Co., Philadelphia.
Horizontal cloth dryer, Riggs & Lombard Inc., Lowell, Mass.
Three-roll padder, Textile Finishing Machinery Co., Providence, R. I.
*Button hole machine, The Reece Button Hole Machine Co., Boston.

Welding

Thin-gage and aircraft welder, General Electric Co., Schenectady, N. Y.
*Arc welder, Allen Electric & Equipment Co., Kalamazoo, Mich.

Woodworking

Reciprocating electric sander, Detroit Surfacing Machine Co., Detroit.
Endless belt sander, Jefferson Machine Tool Co., Cincinnati.

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Agricultural machinery
Air conditioning equipment
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Automobiles

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Bookbinding machinery
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Cement & concrete machinery
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Clothes-pressing machines
Coffee-roasting & grinding machines
Coin-operated machines
Condensers, other than electrical
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Cranes, including hoists & derricks
Crushing, grinding & pulverizing machinery

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Diesel engines
Dish-washing machinery
Dredging & excavating machinery including power shovels
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Lawn mowers
Leather-working machinery not including shoe machinery
Locomotives, rail cars, etc.
Lubricating machines

Machine tools
Metalworking machinery
Meters, gas & water
Mining machinery, not incl. oil drilling
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Motor vehicles, except motorcycles
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Oil-mill machinery, cottonseed & other
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Orecrushers

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Packing-house machinery
Paint making machinery
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Paper-mill & pulp-mill machinery
Permanent wave machines, hair-dryers etc.
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Photo-engraving machinery
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Pneumatic equipment, including compressors
Power presses, including hydraulic & forging hammers
Printers' machinery
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Ships & motorboats
Shoe machinery
Signs, advertising & electrical
Slicing machinery
Special machinery
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Stokers, domestic & industrial
Stone-working machinery
Sugar-mill machinery

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Tobacco manufacturing machinery
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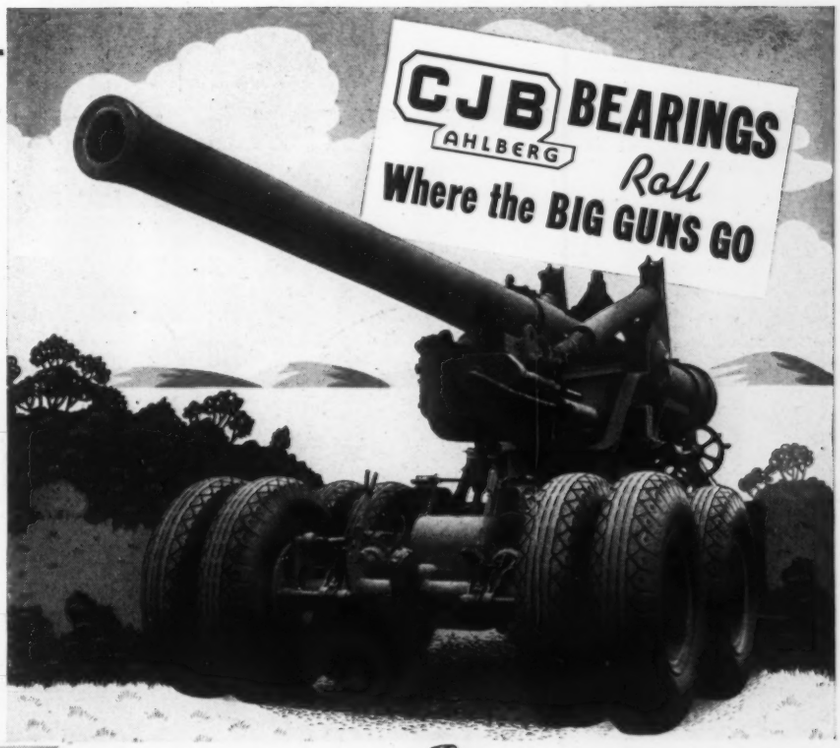

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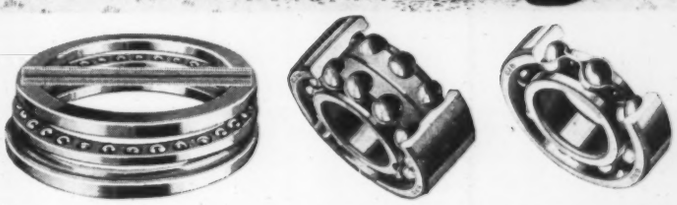

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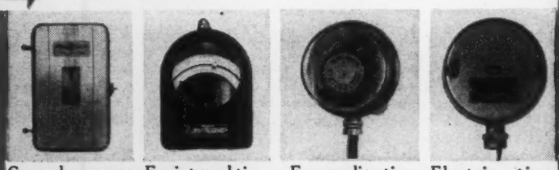

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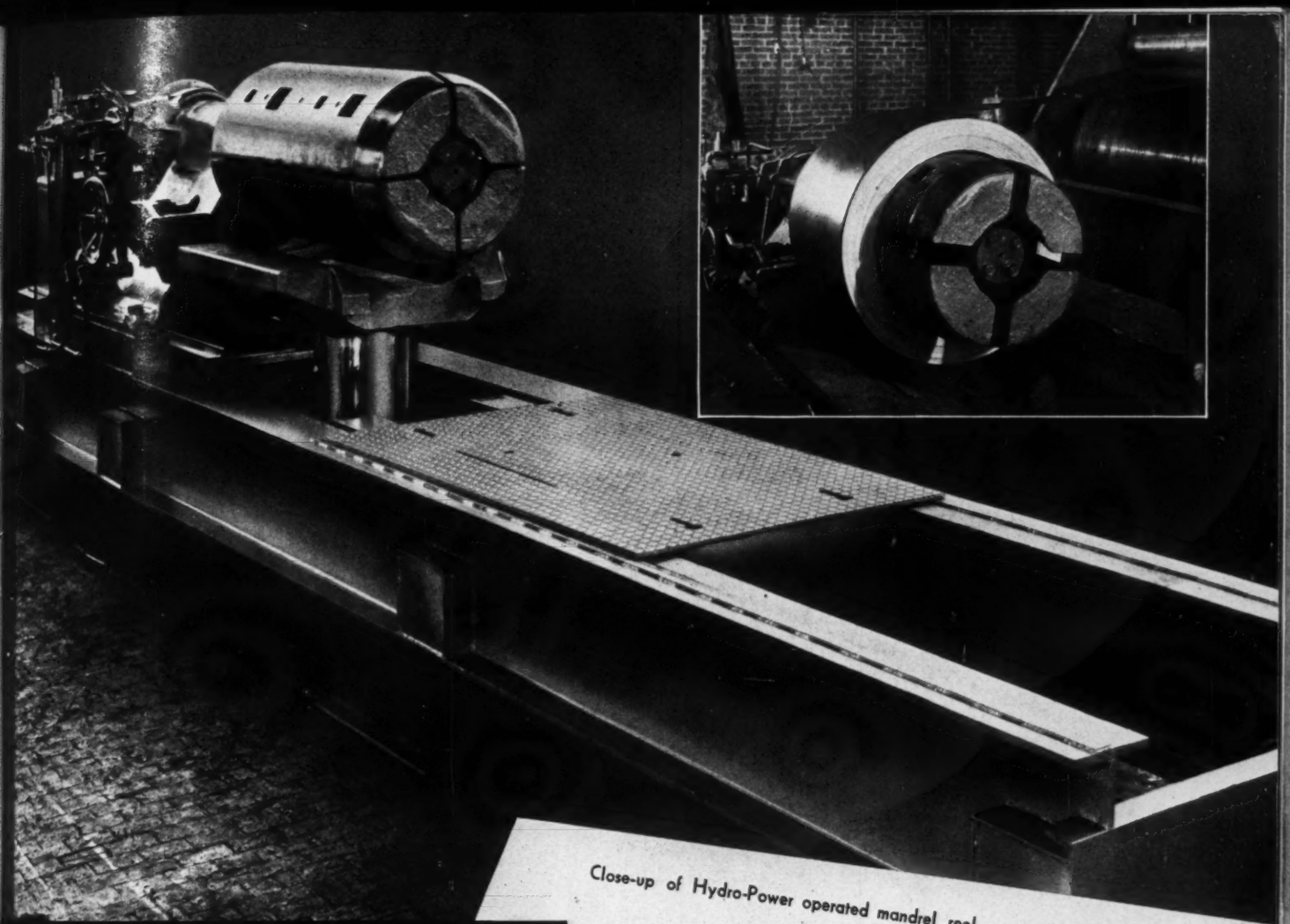
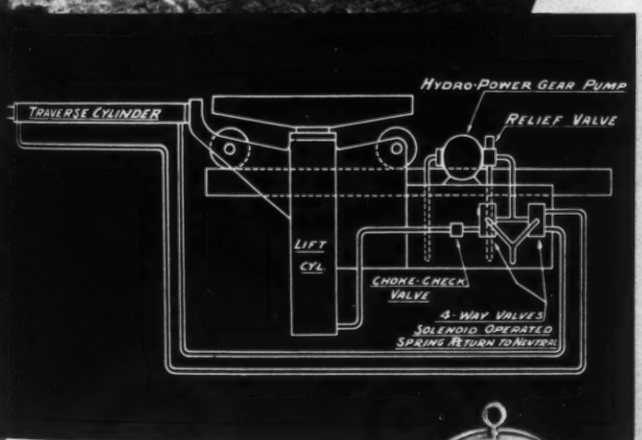
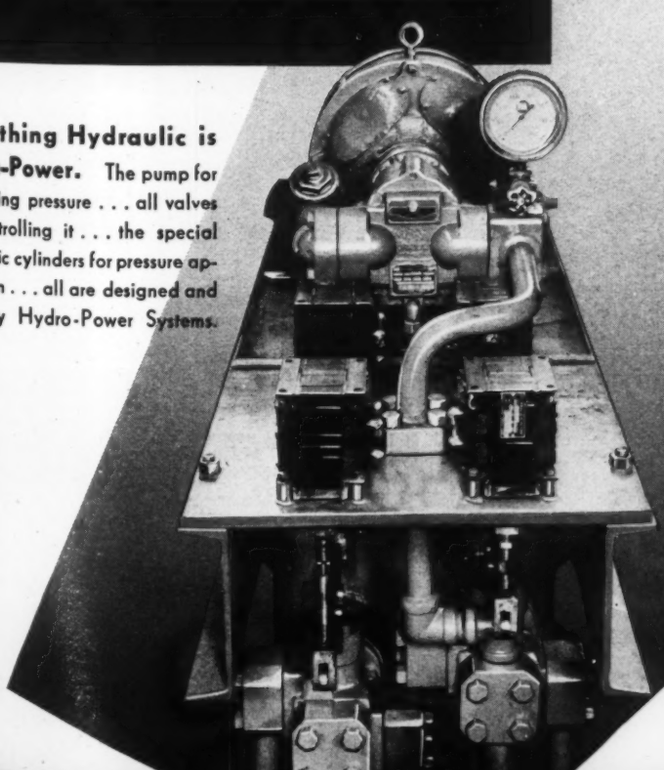


Close-up of Hydro-Power operated mandrel reel paying off strip steel into shear.



HANDLING STRIP STEEL with HYDRO-POWER

Everything Hydraulic is Hydro-Power. The pump for generating pressure . . . all valves for controlling it . . . the special hydraulic cylinders for pressure application . . . all are designed and built by Hydro-Power Systems.



The "Lifetime" heavy duty Hydro-Power pump and simplified hydraulic controls efficiently handle the lifting and traversing of Mandrel Pay-off reel in large steel mill. This "man sized job" is one that must be performed with dependability. Hydro-Power pumps and controls assure this trouble-free performance on any type of Hydraulic power application. Hydro-Power's unparalleled records of efficient, dependable operation can easily be duplicated on your equipment. Hydro-Power engineers will show you how. » » »

HYDRO-POWER SYSTEMS, INC.
Mount Gilead, Ohio, U. S. A.

Irvington

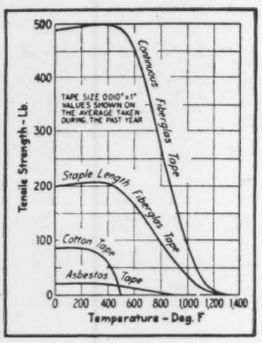
VARNISHED FIBERGLAS INSULATION

for

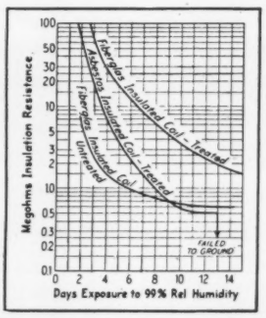
INCREASED DIELECTRIC STRENGTH...
SUPERIOR RESISTANCE TO HEAT AND MOISTURE

IRVINGTON VARNISHED FIBERGLAS is glass cloth woven from continuous fiber, soda-free yarn by Owens-Corning Fiberglas Corporation—then coated and impregnated with specially developed Irvington high-heat resisting insulating varnish to develop its full possibilities.

As an insulation it is superior in heat and moisture resistance and dielectric strength.


Tensile Strength - Lb.
Temperature - Deg. F
TAPE SIZE 0.010"x1" VALUES SHOWN ON THE AVERAGE TAKEN DURING THE PAST YEAR
Continuous Fiberglas Tape
Staple Length Fiberglas Tape
Cotton Tape
Asbestos Tape

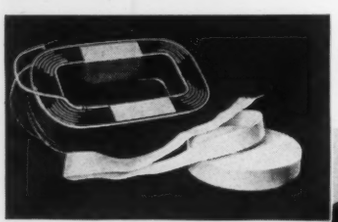
←Tensile strength of Fiberglas superior at higher temperatures. Tape size 0.010 x 1 inch.


Megohms Insulation Resistance
Days Exposure to 99% Rel Humidity
Fiberglas Insulated Coil - Treated
Asbestos Insulated Coil - Treated
Fiberglas Insulated Coil - Untreated
FAILED TO GROUND

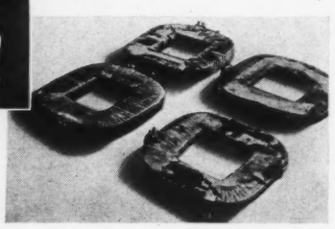
Effect of exposure to 99 per cent relative humidity on coils impregnated with solventless varnish as compared to no treatment.→

Used as Insulation: On motor and generator armatures and field coils, transformer and control coils, electrical equipment for chemical plants to resist corrosion of cables and bus bars, coils and cables where low losses are requirements.

IRVINGTON VARNISHED FIBERGLAS comes in rolls of cloth like fabric, in wide or narrow widths and a variety of thicknesses in two colors, black or yellow.



←Heat resistance of Fiberglas tape on railway motor coil.



Railway field coils after being subjected to 200% overload. In the asbestos insulated coils, the copper had melted. The coil insulated with Fiberglas (upper left) remained in excellent condition.→

For more complete data write Dept. 86.

Irvington VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

STANDARD OF THE WORLD — IRVINGTON INSULATOR

PLANTS AT IRVINGTON, N. J. HAMILTON, ONT., CAN.

Representatives in 20 Principal Cities

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TO MEET widespread demand for R. E. Orton's "Applying Theory of Elasticity in Practical Design", the eleven articles in the series have been made available in convenient bound form. Price, $1 postpaid (orders for delivery in Ohio, 3c additional to cover state sales tax)

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★ ★ ★

MACHINE DESIGN

Book Department

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"BREAK" IS A LOT SMARTER THAN "BROKE"

ALTER EGO: Literally, "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

It takes nerve to BREAK with precedent and change over to making these things by arc welding.

ALTER EGO: It takes a lot more than nerve to keep on making them the way we do—when we KNOW they cost more—when we KNOW welding will improve both the product and the output. That's more than nerve. It's CRUST.

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• •

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THE LINCOLN ELECTRIC COMPANY
Cleveland, Ohio

Authoritative Information on Design • Production • Welding Equipment

Another nationally famous user of

MASTER MOTORS

To maintain their position of leadership SCHENLEY DISTILLERS CORPORATION uses the best of materials and the finest of processing equipment. Schenley engineers find that their plant equipment is improved, made more compact, lower in cost, more convenient, more safe by using Master motors that meet the requirements exactly of each individual application.

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MASTER

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The wind tunnel shown above is installed at the plant of the Lockheed Aircraft Corporation. Its huge propeller will move the air at a speed of more than 310 miles per hour for aero-dynamic tests of modern aircraft design.

Power is applied to the propeller through a big right-angle gear drive manufactured by Pacific Gear Works of Los Angeles. H.P. rating, 1280 normal, 2500 overload. Input speed, 800 R.P.M. The bevel pinion and bevel gear shafts of this drive are both mounted on Timken Tapered Roller Bearings.

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TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

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Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

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